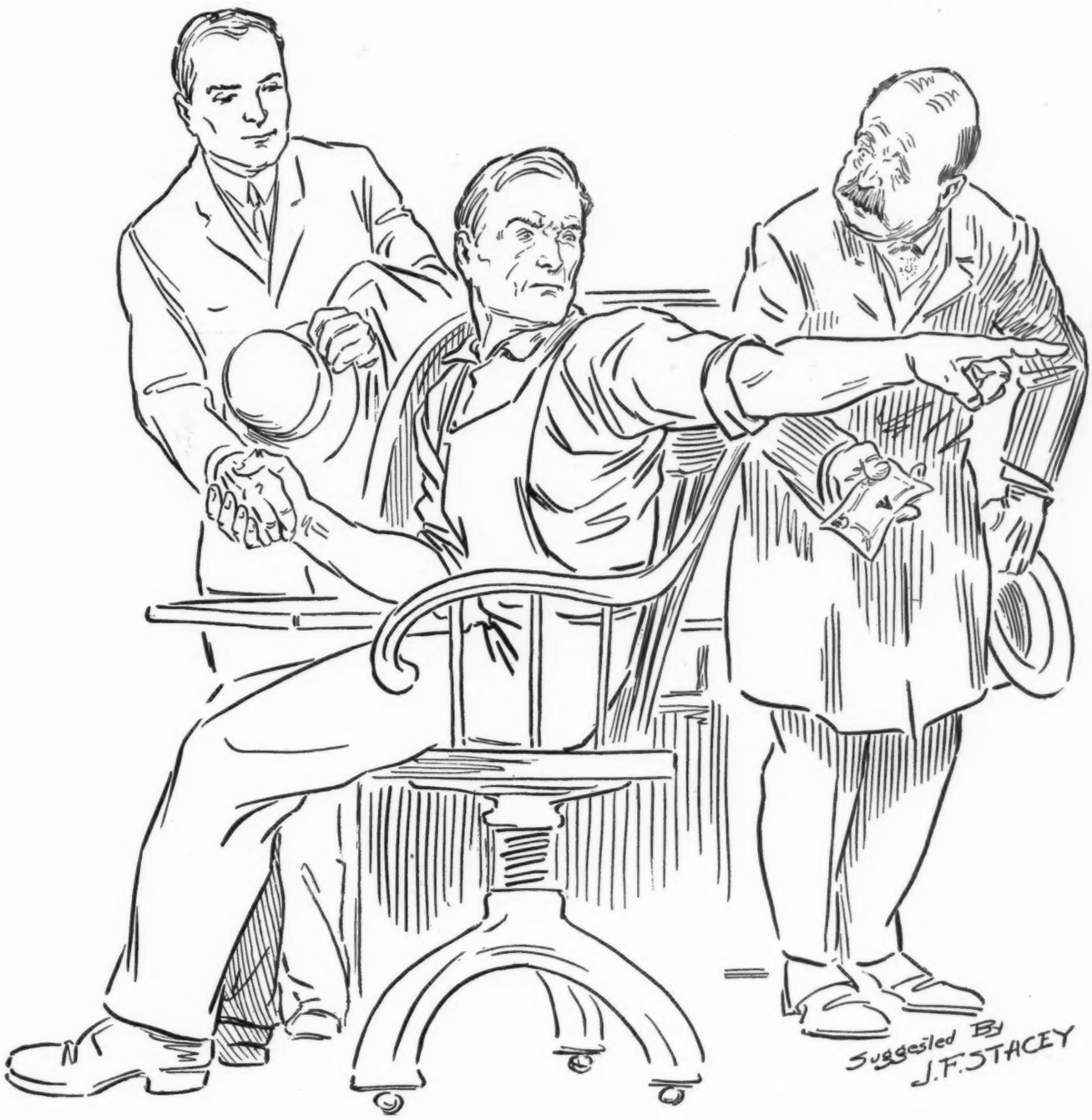
POWER

Vol. 39 NEW YORK, APRIL 21, 1914 No. 16



HONEST GOODS ARE SOLD BY HONEST METHODS

Improvements in Stand-By Station at Greenfield, Mass.

By Warren O. Rogers

SYNOPSIS—A steam-turbine stand-by plant used as a distributing station; it is tied in with a hydro-electric station and one other steam plant. Additional energy is purchased for 0.5c. per kilowatt-hour, which is less than the cost of coal at the steam plant.

Although hydro-electric power plants have advantages over steam stations as to operation and maintenance costs, there is the necessity of maintaining a steam stand-by station to safeguard the service against serious interruption. This is the practice of the Greenfield (Mass.) Electric Light & Power Co., which operates a hydro-electric power plant at Gardner Falls, on the Deerfield River, and also maintains a stand-by steam plant at Greenfield.

The water plant originally had two 400-kw. generators, but recently two 1450-hp. turbines and two 1170-kv.-a. generators have been added to the equipment. The new units operate at 150 r.p.m. under a 37-ft. working head. There is also a 135-hp. hydraulic turbine, driving a 60-kw. exciter. The cost of the improvements at the hydro-electric station was $60,250, divided as follows: Water turbines, $11,500; electrical apparatus, $29,500; switchboard and incidentals, $15,000, and for alterations to the building, its foundation, etc., $4250.

In addition, changes have been made in the Greenfield steam station, there having been installed two 500-hp. porcupine boilers, costing $11,500, and a four-stage, 2000-kw. Curtis steam turbine for about $30,000, a total of $41,500. For both the steam and hydro-electric plants, the total improvements have cost $101,750.

The original steam plant consisted of a 635-hp. Stirling boiler and a reciprocating engine. Later, three 250-hp. porcupine boilers and a 750-kw. five-stage turbine were installed. The engine has been removed and the Stirling boiler is held as a stand-by unit. The plant contains six boilers with a total boiler horsepower of 2385. The two turbo-generators have a total capacity of 2750 kw., as against 3140 kv.-a. at the hydro-electric plant.

The small steam-turbine unit generates 2300-volt, three-phase, 60-cycle current, at 1800 r.p.m., with 130 lb. steam on the turbine. The larger unit runs at 1800 r.p.m. and generates current at the same voltage.

Exciters

There are three exciter units, one turbine-driven, and the others motor-driven. The turbine unit is a 25-kw. turbine and a 25-kw. direct-current generator delivering 150 volts at 3600 r.p.m. This unit is used only when all the others are in operation and all lines are dead. The smaller motor-driven units consist of a 30-hp. induction motor and a direct-current 125-volt generator at 900 r.p.m. The other 50-kw., 125-volt, direct-current generator is driven by a 75-hp. induction motor at 1200 r.p.m. The main units and exciters are shown in the general view, Fig. 1.

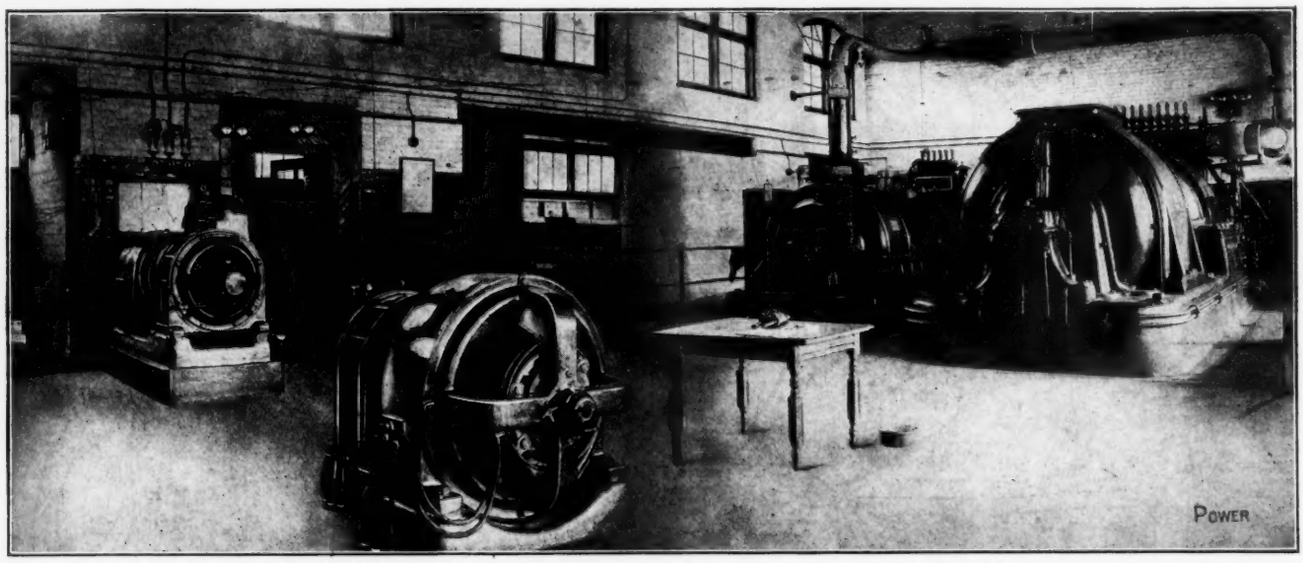


Fig. 1. Partial View of the Greenfield, Mass. Stand-by Station. The 750- and 2000-Kw. Turbines Are Shown in the Background

Boiler Room

The vertical boilers are set with dutch-oven furnaces. Three are hand-fired and two have chain-grate stokers, two to each furnace, with a firebrick wall between each, extending the length of the furnace. Each stoker is but 3 ft. 3 in. wide and is 15 ft. 6 in. long, 50.4 sq.ft. or a total of 100.8 sq.ft. of grate area per boiler. The boiler-heating surface is 5900 sq.ft., or 58.8 sq.ft. per square foot of grate surface.

The three smaller boilers each have 2949 sq.ft. of heating surface, with a grate area of 7½x8½ or 63¾ sq.ft.;

this gives 46.3 sq.ft. of heating surface per square foot of grate area. The 635-hp. Stirling boiler contains 5688 sq.ft. of heating surface, with a grate area of 133 sq.ft., or 42.6 sq.ft. of heating surface per square foot of grate.

FIG. 2. FIVE PORCUPINE BOILERS AND DUTCH-OVEN FURNACES. TWO ARE STOKER AND THREE HAND FIRED

cylinders and runs at 180 r.p.m.; it can also be operated with the large turbine condenser as a wet-air pump.

The large turbine exhausts into a two-pass surface condenser, having 6000 sq.ft. of cooling surface, or 3 sq.ft. per kilowatt of the turbine rating. The surface condenser is supplied with circulating water by a 15-in. centrifugal pump, driven by an 8x10-in. horizontal reciprocating engine at 200 r.p.m. with a capacity of 5250 gal. of water per minute. The condenser equipment is

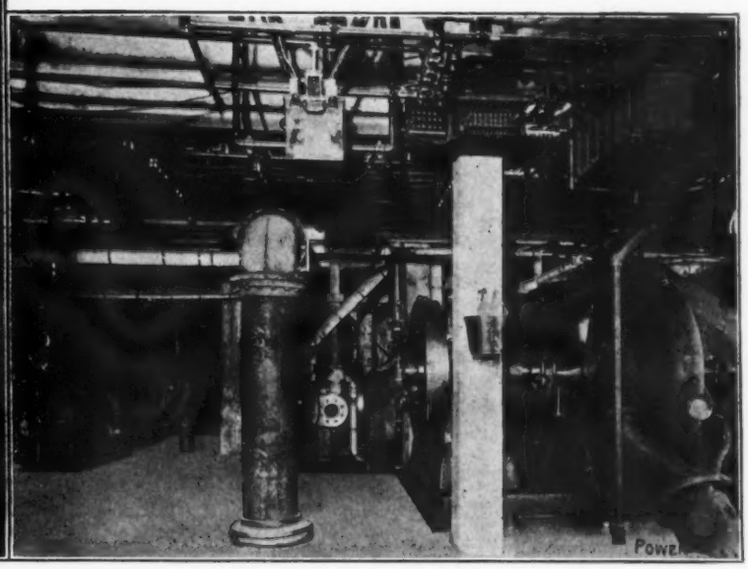


FIG. 3. JET AND SURFACE CONDENSER EQUIPMENT IN THE BASEMENT. THE RESISTANCE BOXES AND WIRING ARE HUNG FROM THE CEILING

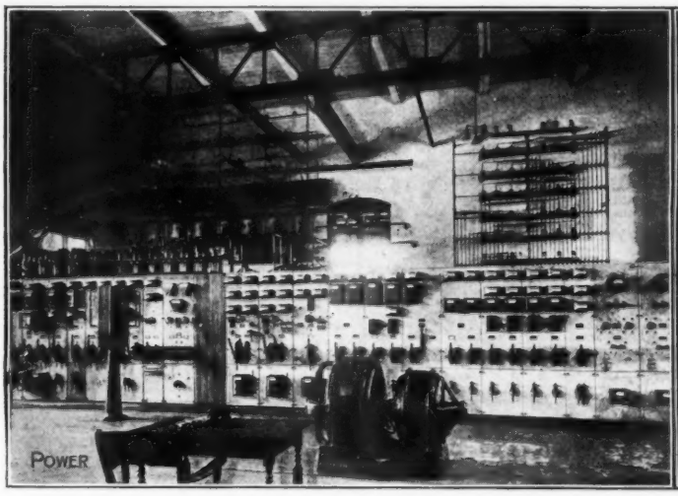


FIG. 4. MAIN SWITCHBOARD. THE WIRING AT THE RIGHT IS FOR 11,000-VOLT CURRENT

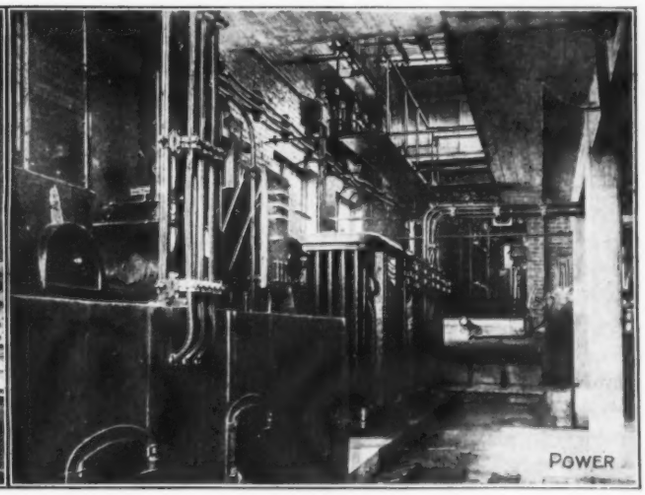


FIG. 5. OIL- AND AIR-COOLED TRANSFORMERS IN THE BASEMENT

The stoker-fired boilers, it will be noticed, have a higher ratio of heating surface per square foot of grate area than the hand-fired boilers. A view of the porcupine boilers is shown in Fig. 2.

CONDENSERS

The small turbine is served by a jet condenser. The injection water is supplied by a 12-in. volute pump, turbine-driven. The dry-air pump has 8 and 18 by 12-in.

shown in Fig. 3. The condensing water was formerly pumped to the station, but it now comes by gravity.

TRANSFORMER AND CONVERTERS

The rotary converters are in a room adjoining the turbine room, but about 4 ft. lower. These units consist of two 200-kw. rotary converters with a direct-current output at 600 volts and 1200 r.p.m. There is also one synchronous condenser floating on the line with a starting

motor mounted on the shaft extension. A general view of the main switchboard for controlling these and other units is shown in Fig. 4.

Out in the condenser basement there are three 300-kw., 11,000-2300-volt, air-cooled transformers. The two cooling fans are each driven by a 2-hp. motor. This apparatus is placed on a concrete shelf, as in Fig. 5, with the air ducts encased in the concrete. The three 250-kw. transformers are oil cooled and transform from 11,000 to 2300 volts; they are placed on a concrete platform slightly raised above the basement floor. The mercury arc rectifiers are shown at the right, back of the supporting pillars. In a separate building there is a 270-cell storage-battery system, which works in parallel with a booster set and aids the station over peak loads.

Pumps

The boiler-feed pumps consist of one 9 and 6 by 12-in. duplex outside-packed unit and one turbine-driven triplex, 3-in. centrifugal pump with a capacity of 200 gal. per min. at 2500 r.p.m. The feed water is heated in an open heater.

Electrical Transmission

In connection with the steam plant, which is only run occasionally, there are the Gardner Falls hydro-electric plant and a steam plant at Easthampton; and a substation at Northfield. These plants are situated to give a strategic position with reference to neighboring developments and from the standpoint of economical production of electrical energy.

In addition to what energy is developed in the three plants of the company, surplus energy is purchased from the hydro-electric plant of the Turner Fall Power Co. at about 0.5c. per kilowatt-hour. This is less than the cost of coal used at the Greenfield station when running at full capacity. By using this purchased energy in addition to that generated at the Gardner Falls plant throughout about eight months of the year, the cost of electrical energy to the Greenfield company is said to be lower than for most other plants in the state.

Gas-Producer Testing

By Everard Brown

SYNOPSIS—Maintaining test conditions, taking readings and samples and working up results of test.

In order to establish the maximum efficiency of a gas producer, it is necessary to run a test of sufficient duration to give positive results under different conditions of operation. For example, various depths of the fuel bed and of the different zones should be tried as well as different blast pressures and quantities of steam, etc. It is a certain combination of these that will give the best results. If it is desired to experiment still further, different grades of coal can also be tried, in order to determine which, all things considered, gives the best results.

Weighing the Coal

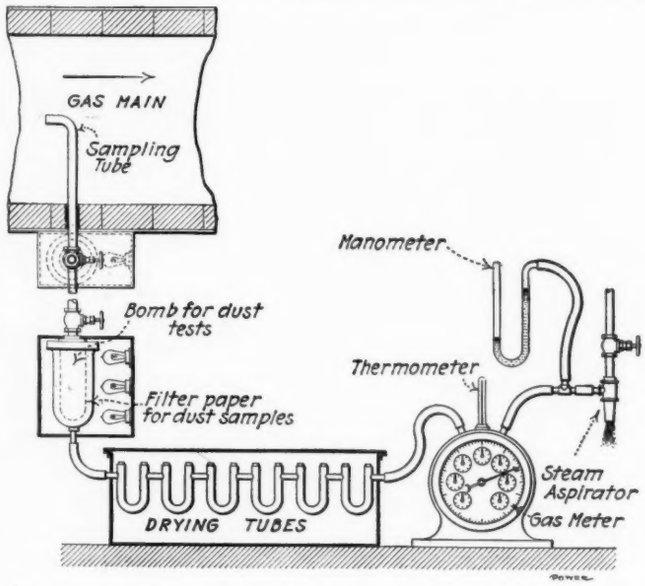
The simplest way is to place a box that will hold, say, 500 lb. on a platform scales at the top of the producer and convenient to the hopper. Coal can then be shoveled into the box and weighed and then shoveled into the producer hopper and charged as the rate of gasification demands. Each box of coal should be noted on the records. Small samples for analysis should be taken from each boxful and placed in a comparatively tight storage box.

Both proximate and ultimate analyses are desirable. If it is not convenient to make them within a short time after taking the samples, take separate samples for moisture determinations and make these determinations at once.

Fuel Bed and Zones

There are three distinct zones in a gas producer: The ash, the combustion and the distillation zones, and the proper depth of each is important.

The depth of the fuel bed and the uniformity of distribution can be ascertained by inserting a small-diameter pipe or rod through the poke holes at the top. It is well to slip a loose flange over the pipe or rod so as to cover the poke hole and prevent excessive leakage of gas. Marks filed on the rod and spaced 6 in. apart will greatly facilitate the work of taking these readings and reduce the chance for errors. These dimensions from the top of the fuel bed to the top of the producer, subtracted from the total dimension (from the top of the blast cone to the top of the producer) will show the total depth of fuel above the cone. If possible, measurements should be taken at several points both near the shell and toward the center of the producer.



Arrangement for Sampling and Testing Moisture and Tar in Gas

To measure the depths of the various zones, a similar method may be used. In this case push the rod down through the fuel bed until it strikes the top of the blast cone and leave it there for three or four minutes, then

withdraw it and measure the different depths indicated by the colors of the rod. The rod will show three distinct zones or colors; the ash zone appearing black, the combustion zone yellow and the distillation zone dark red.

Two rods should be used simultaneously for these determinations, one at the center and the other near the shell to determine the fuel distributions. Both the fuel depth and zone depth measurements should be taken about every half hour.

Samples and Analysis of Gas

Gas samples should be obtained from the main about 20 ft. from the top of the producer so that the gas may be given an opportunity to become thoroughly mixed.

The simplest apparatus for taking these samples consists of a small piece of ¾-in. pipe, one end having a tee. To one side outlet of this tee attach a nipple to which the aspirator bottles can be connected by rubber tubing; in the other side insert a plug. The object of this tee is to permit of cleaning.

If possible, the gas samples should be taken continuously, or at frequent intervals, and as soon as a full sample is obtained it should be analyzed. If this is not convenient, seal the sample bombs with paraffin; if well prepared, the samples taken during the night can be analyzed the next day.

Gas Temperatures

Gas temperatures can be measured by means of a thermo-couple and an indicating galvanometer. The couple should be inserted into the main near the producer and kept there continuously during the test except for a few minutes about every 10 hr., when it should be removed to clean the soot off the protecting tube. To make corrections for the increased resistance, due to the heating of the "cold junction" of the couple above its calibrated zero mark, a mercury thermometer should be so suspended that its bulb will rest on the junction, thus showing to how much this heating amounts.

Soot and Tar

The apparatus necessary for sampling the soot in the gas consists essentially of a sampling pipe, a bomb or holder for filter paper, a supply of filter paper, a wet-gas meter and a steam-aspirating attachment.

A piece of ¾-in. pipe having one end bent at right angles may be used as a sampling pipe. To the other end attach a valve and a short nipple. A plug can be screwed into this open end when not in use. To the nipple connect the bomb or holder containing the filter paper and this in turn to the wet-gas meter. The steam aspirator is, of course, attached to the outlet side of the meter. To prevent condensation in the bomb it should be incased in a wooden box in which there are sufficient incandescent electric bulbs to generate enough heat to keep the temperature above 212 deg. F. It is also advisable to provide the meter with a thermometer and a manometer, or gage, so that the temperature and pressure of the gas can be noted. This arrangement is represented in the sketch.

The samples are usually taken in the following manner:

First insert the bent end of the sampling pipe in the main as near to the producer as possible, with its orifice pointing against the direction of flow. Connect up the rest of the apparatus and place the filter paper, after being carefully weighed, in its container and turn on the lights. When the wooden box is heated, the valve on the sampling pipe can be opened and the steam is turned into the aspirator. See that the sampling pipe does not become clogged.

As large a volume of gas should be sampled as the filter paper will permit; this should be at least 3 cu.ft. When the paper has become so clogged with deposited matter that it is almost impossible to aspirate any more gas, this soot and tar are dried, weighed and analyzed for carbon and hydrogen. It is necessary to take soot and tar samples only two or three times a day.

The method outlined will not give an absolutely true sample of tar, but the error involved is insignificant. The inaccuracy is due to the gas containing some tar in the form of vapor, and as long as the pores of the filter paper are open, some tar vapor will pass through. This fact can be observed in the discolorization on the under side of the filter paper after some of the gas has passed through.

Moisture Determination

The apparatus required for determining moisture in the gas is the same as that for soot and tar, with the addition of a series of calcium-chloride tubes inserted between the filter and the meter. To get samples of a larger volume of gas, cotton may be substituted for the filter paper as it will allow more gas to pass through before becoming clogged. In this case especial care should also be taken in heating the bomb so that no moisture will be absorbed by the cotton.

There should always be at least six drying tubes to insure the precipitation of all the moisture in the gas. This can be ascertained after a sample is taken by examining the last tube through which the gas passes. If it contains no moisture, or only a trace, the indications are that the gas is dry. Some tar vapors may also be condensed and are indicated by the discolorization of the calcium chloride in the first three or four tubes. This cannot well be avoided.

The tubes are weighed and the difference between this weight and that of the tubes before taking the sample, is the weight of moisture contained in the volume of gas passed through, as shown by the meter. After each sample is taken some of the tubes should be cleaned, dried and refilled. By doing this in rotation each tube is put into good condition for every third or fourth sample taken, thus insuring more accurate results. The samples for moisture should be taken alternatively with those for soot and tar.

Pressure and Quality of Steam

The pressure of the steam for blowing the producer is determined from the gage which should be carefully calibrated before and after the test, and which should be connected near the steam nozzle.

The weight of the steam can be calculated from Napier's formula for the flow of steam through nozzles; namely,

$$W = \frac{P \times a}{70}$$

Where

W = Weight of steam per second;
P = Pressure in pounds absolute;
a = Area of nozzle in square inches;
70 = A constant for all pressures above 25 lb. absolute.

A separating calorimeter will establish the quality of the steam with sufficient accuracy.

Other Pressures and Temperatures

To ascertain the gas pressure a water manometer should be connected to a short pipe inserted in the gas main near the producer and in such a way that friction losses will be a minimum. The atmospheric pressure can be recorded by means of a barometer.

A psychrometer or an ordinary wet-and-dry-bulb thermometer will determine the temperature and humidity of the atmosphere. This should be placed near the blower of the producer and if a wet-and-dry-bulb thermometer is used, care should be taken to keep the covering of the wet bulb well moistened at all times.

Steam- and gas-pressure readings should be taken every 10 or 15 min.; the other readings need not be taken so frequently.

Ash Samples

These samples can be stored temporarily in a box having a capacity of about 100 lb. so that, at the end of the test, the total samples taken will fill the box. From this quantity two or three average samples should be taken and analyzed for carbon and iron. The samples should be taken at intervals not exceeding an hour.

Tabulating Results

Probably the best way to tabulate the results is by showing graphically the hourly averages; one set of curves showing the gas temperature and pressure, another the steam pressure and weight of steam blown; another the pounds of coal gasified per square foot of grate area and the pounds of coal gasified per hour; another the heat value and composition of the gas, and another the depth of the distillation, combustion and ash zones.

A ready analysis of the results can be made by plotting these sets of curves, one above the other, on the same sheet of cross-section paper, so that respective ordinates will indicate simultaneous readings for all.

Other conditions being equal, the carbon dioxide and hydrogen curves will generally rise with the steam curves and *vice versa;* also the gas temperature and carbon-monoxide curves will fall with a rise in the steam curves. The hydro-carbon curves, in general, rise as the gas temperature falls and fall as this temperature rises, thus showing that they suffer decomposition at the higher temperatures. This fact is further borne out by the soot determinations because invariably the quantity of soot per unit volume of gas is large when the gas temperature is high.

It may be rather difficult to form a definite conclusion as to what combination of events is most favorable to the production of good gas, as a gas that is best for one purpose is not always best for another. In general, a good producer gas is one in which the sum of the carbon gases approaches 36 per cent. of the total gases. Of this percentage about 3 per cent. may be incombustible in the form of carbon dioxide. Such a gas would analyze about as follows: CO_2, 3 per cent.; CH_4, 3.5 per cent.; CO, 29 per cent.; H_2, 12.5 per cent.; N_2, 52 per cent.

It must also be remembered that the best producer is not always the one that generates the greatest volume of gas; in fact, the volume of a good producer gas should hardly exceed 85 cu.ft. per pound of carbon gasified.

The carbon loss in the ash and soot is another point that must not be overlooked because this can often be controlled. Usually, carbon losses in the soot are conditional upon the gas temperatures, and are, therefore, largely influenced by the method of operating the producer. Good practice has established for soot losses a range of from 3.5 to 4.5 per cent. of the total carbon in the coal.

The loss due to carbon in the ash should never be much greater than 1 per cent. of the total carbon in the coal. A clearer conception of the losses due to the presence of carbon in the ash and soot will be had if reduced to percentages of the total coal charged. The quantity of gas in cubic feet as measured by the meter under test conditions should be corrected for standard conditions; namely, the gas volume at 30 in. of mercury and 62 deg. F.; the absolute temperature of the gas at standard conditions, 522 deg. F.; and a standard pressure of 30 in. of mercury. The following formula will give corrected figures for the gas volume:

$$V_1 = \frac{T_1}{T} \times \frac{p}{p_1} \times V$$

where

V_1 = Gas volume at standard conditions (30 in. of mercury and 62 deg. F.);
T_1 = Absolute temperature of gas at standard conditions (522 deg. F.);
T = Absolute temperature of gas at meter conditions;
p = Pressure at meter conditions;
p_1 = Standard pressure (30 in. of mercury);
V = Gas volume at meter conditions.

The corrected pressure may be obtained by the following:

$$P = P_1 - P_2 - t$$

where

P = Corrected pressure;
P_1 = Barometric reading in inches of mercury;
P_2 = Manometer reading in inches of mercury;
t = Vapor tension reading in inches of mercury.

Producer Efficiency

From the various data obtained during the test it is a comparatively simple matter to determine the efficiency of the producer. The calculation is, of course, made on the unit basis of the gasification of 1 lb. of coal. Furthermore, there are two efficiencies to consider, the cold-gas efficiency and the hot-gas efficiency. The only difference between these is that the former does not take into account the sensible heat of the gas, whereas the latter does, making the hot-gas efficiency higher.

To determine the cold-gas efficiency the producer is first credited with the total B.t.u. per pound of coal charged. To this must be added the B.t.u. in the coal consumed in generating sufficient steam to gasify 1 lb. of coal. Also, if the producer tested is mechanically operated, the heat units in the coal required for its mechanical operation must be added. This sum divided into the product of the number of cubic feet of gas generated per pound of coal by the number of heat units per cubic foot of gas and then multiplied by 100 equals the cold-gas efficiency. Expressed as a formula, this calculation is as follows:

$$\frac{V \times h}{H_1 + H_2 + H_3} \times 100 = \textit{efficiency in per cent.}$$

where

V = Cubic feet of gas generated per pound of coal;
h = B.t.u. per cubic foot of gas;
H_1 = B.t.u. per pound of coal charged;
H_2 = B.t.u. in coal for generating steam to gasify 1 lb. of coal;
H_3 = B.t.u. in coal required for mechanical operation of producer.

The hot-gas efficiency may be represented by the formula:

$$\frac{V \times (h + h_1)}{H_1 + H_2 + H_3} \times 100 = \textit{efficiency in per cent.}$$

where h_1 is the sensible heat of the gas.

As a rule, it is hardly fair to charge the producer with steam used for blowing at 100 per cent. quality because it usually contains some moisture. This moisture is precipitated to a large extent in the injector and, therefore, does not enter the producer. Furthermore, this moisture may be due to condensation resulting from the relative locations of the producer and boilers and consequently is wholly independent of the former.

The amount of carbon gasified is equal to the total carbon in the coal minus the sum of the carbon in the ashes and soot. It is also evident that the total heat units in the coal minus the total heat units in the gas, ashes and soot will determine the heat losses due to radiation, etc.

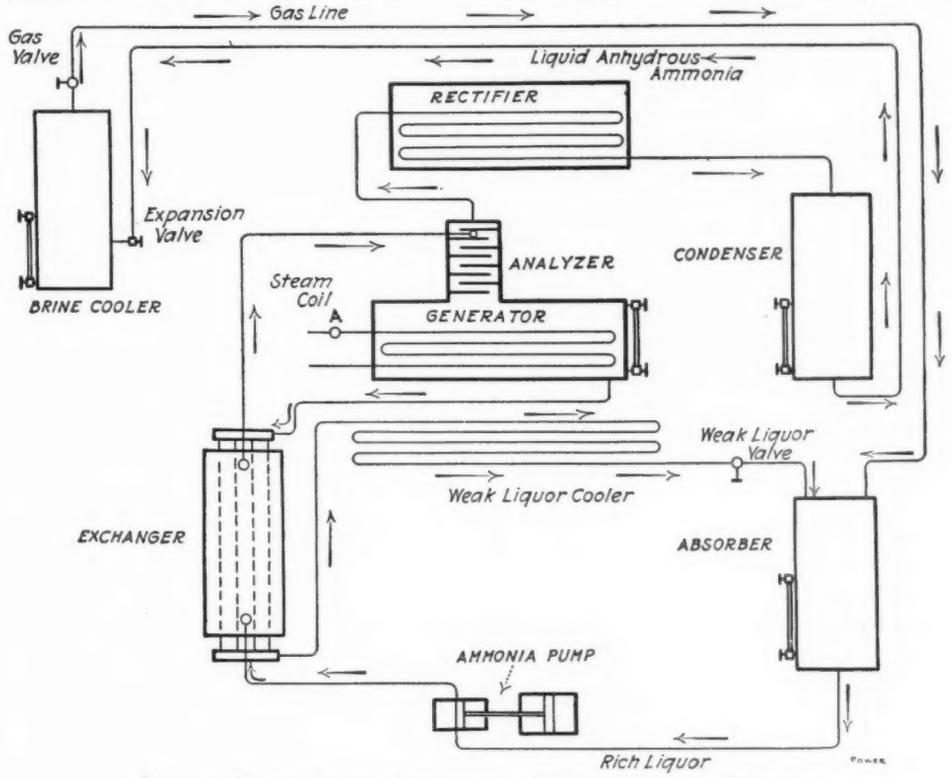
Starting and Stopping an Absorption Refrigeration Plant

By R. F. Proffitt

SYNOPSIS—An article for engineers not familiar with the system. Tells how to start and stop the plant and gives hints on purging and care.

How the Absorption System Works

This article is intended for beginners. So as not to confuse the reader, the writer has left out of the diagram the water connections and valves not needed for starting and stopping the machine. It must be understood that the cooling water is a most essential part of this as of other refrigerating systems. Cooling water flows either through or over coils, in the condenser, absorber, rectifier and weak-liquor cooler. The system is charged with a mixture of water and anhydrous ammonia which is contained in the generator or still. Steam is circulated through the coils submerged in the aqua ammonia to heat the latter until the ammonia gas is driven off through the analyzer to the rectifier and into the condenser at a pressure corresponding to its temperature. In going through the analyzer most of the entrained moisture is separated from the gas by the baffles shown in the diagram. If there is any moisture left, it is picked up by the rectifier and returned to the generator. The rectifier partly cools the gas before delivering it to the condenser where it is condensed and becomes liquid anhydrous, which falls to the bottom of the condenser, and is then ready to be expanded in the brine cooler. It is admitted to the brine cooler through the expansion valve. After passing the valve it enters the cooler and the pressure is released as it is now expanding in a large space, absorbing heat from the brine which it cools. This process completes the operation of refrigeration, but the original conditions must be duplicated so that the operation may begin again. We now have the expanded ammonia at a very low pressure, and this must be returned to the generator again. To do this we have to use the ammonia pump and the absorber. By admitting the water or weak liquor that is left in the generator into the absorber, together with the gas from the cooler, the weak liquor absorbs the gas; hence the name absorber. As the weak liquor is at a high



Simple Diagram of Absorption Refrigeration System

temperature it is cooled first before entering the absorber; it is cooled still more by contact with water-cooled coils in the absorber. It is now in its original state. The weak liquor is comparatively cool, however, so it is pumped through the exchanger where it meets the hot, weak liquor coming from the generator. The two liquids travel in opposite directions, the weak liquor entering at the top and passing out at the bottom, and the strong liquor entering at the bottom and passing out at the top. The strong liquor now enters the generator; the weak liquor is cooled more by going through the weak liquor cooler before entering the absorber as can be seen by the diagram. This completes the cycle of operation, and this process is continued until the brine is cooled. The brine is circulated through the ice boxes or tanks to be cooled as long as required.

Starting the System

In starting the system, turn on all the water valves and be sure that the water is circulating properly. Open the steam valve *A*. Next open the weak-liquor valve about one turn. Start the ammonia pump slowly by opening the throttle valve. There is a governor on the pump steam line to control the speed of the pump so as to maintain a certain level of liquid in the absorber. It is best to operate the pump by the throttle valve until the system has reached its proper working condition so as not to lose the pump suction when the gas valve is opened, which is done after the ammonia pump is started. Open the gas valve slowly until wide open. Next, crack the expansion valve. This valve should be opened just enough so that by listening with your ear close to the valve you can hear the liquid going through with a slight singing noise but steadily, and so that a constant level is maintained in the gage-glass of the receiver. Enough steam should be admitted to the generator to bring the pressure up to about 180 lb. on the generator gage, but no higher. The pressure may be less according to the conditions, and can only be found by experiment. The pressure is governed by the amount of steam, the temperature and the amount of cooling water on the condenser.

Shutting Down the System

In shutting down, first close the expansion valve. Shut the steam valve on the generator, and allow a short time to elapse for the absorber pressure to drop to about one-third normal to allow the gas, still in the cooler, to get over to the absorber; then close the gas valve. Shut down the ammonia pump and wait a while to let the absorber liquid level rise a few inches to give a supply for starting up again. Close the weak-liquor valve and then shut all the water valves. Always bear in mind that the water is turned on first in starting up, and shut off last in stopping. The engineer should make a study of ammonia, and find out what it is composed of, and what it will do under different conditions, what gases it will form when mixed with air and oils and other foreign matter, as he will know then what is the trouble with the system when it does not work properly. Foreign or permanent gases will form in the system and should be purged off as soon as they appear.

Purging the System

Purging valves will be found at the top of the absorber, brine cooler and the condenser. These gases, if left in the system, impair the efficiency of the machine and should be purged off as soon as possible. Purging into a pail of water is the best way, as you can then tell when the foreign gases are all gone. Purge slowly, and as long as bubbles appear on the top of the water, continue even if there is a slight odor of ammonia. There is no serious loss, as the ammonia that comes over with the foreign gas is of no use to the system as it will not condense. Foreign gases are usually lighter than pure ammonia gas. The writer worked with an engineer who did not believe in purging as he thought he would lose much anhydrous ammonia by doing so. The plant had not been purged in three years and the result was that in summer when he needed most work out of the system it would not work at rated capacity. He blamed it on the machine not being large enough to meet the conditions, and yet experts had allowed a large surplus for increasing load. In another plant there was a 12-ton system and the engineer purged frequently and was getting 20 tons out of it easily. There is nothing about this system to bother one if one will study the system under different conditions and experiment at odd times by making different adjustments of valves.

Porous Brasses

Capt. F. W. Bartlett, in the February *Journal* of the American Society of Naval Engineers, tells how porous brasses were treated on the main engine shafts of the armored cruiser "Montana."

Although the brasses were inspected and tested under pressure at the time of fitting, when in service they permitted water to leak through and mingle with the oil to a slight extent. An examination showed the babbitt to be in excellent condition. The moisture apparently crept through small crevices to points under the babbitt, thence to the edges and slowly exuded from under it. In some instances, small drops appeared where there was no babbitt.

Method Used

The brasses were first filled with gasoline and subjected to a pressure of about 20 lb. and left in this condition for 12 hr., the object being to thoroughly cleanse the crevices of oil and water. As was expected, the gasoline slowly worked through.

The gasoline was then removed and air blown through for about four hours, after which the brasses were filled with shellac and kept under 75 lb. air pressure for another four hours, the intention being that the shellac would not set materially in that time. The alcohol in the shellac seemed to push ahead of it small particles of water or gasoline, and appeared as drops at the crevices. In some cases, the shellac could be seen to have passed through these crevices and to have deposited on the outside as a brown liquid. This soon congealed and no further leaks took place. The shellac was then removed from the surfaces, and air blown through the brasses for two or three hours with the idea of setting that remaining in the pores.

Upon testing the brasses for an hour with water at a pressure of approximately 75 lb., there was no sign of leakage, showing conclusively that the pores had been filled.

Warren Manufacturing Company's Plant

By Warren O. Rogers

SYNOPSIS—Some features found in a cotton-mill power plant. Low flue-gas temperatures due to the method of baffling the boilers. Superheated steam from two boilers mingles with saturated steam from nine others, superheating the steam in the main between 20 and 25 deg. This results in but little condensation in the steam lines, the longest of which is 600 feet.

Combining saturated steam and steam superheated 125 deg. in the steam mains leading to the engine units is the novel practice followed in the power plant of the Warren Manufacturing Company's cotton mill at Warren, R. I.

In 1889 this company had the distinction of operating a 2000-hp. quadruple, cross-compound condensing engine.* Later on, the mill and engine were destroyed by fire. When the new mill was built a 32½ and 68½ by

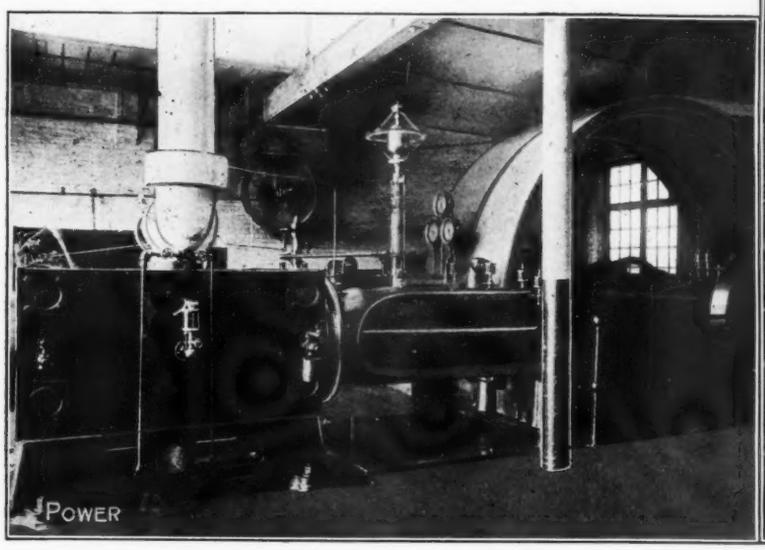


Fig. 1. One-Thousand Horsepower Cross-Compound Corliss Engine

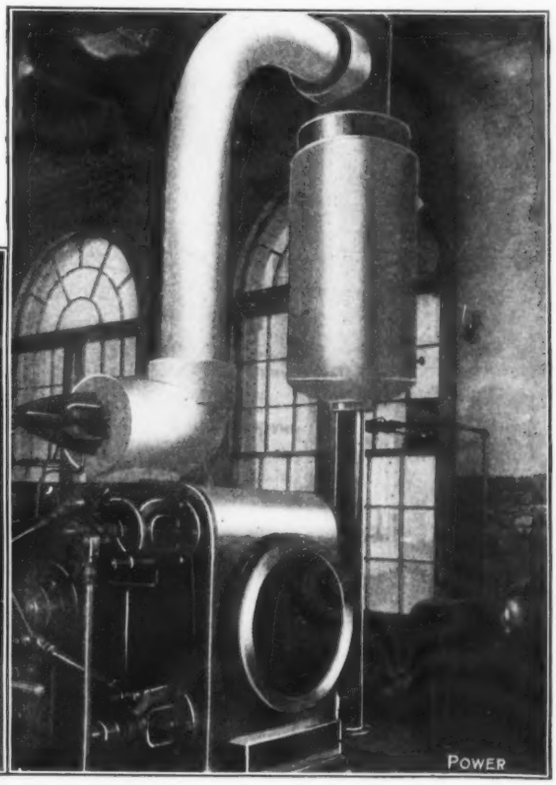


Fig. 2. Separator at End of 600-Ft. Pipe Line and Idle Steam Trap

60-in. vertical cross-compound engine was installed which is now in operation. It develops 2500 hp. at 76 r.p.m. A feature in its piping is interesting in that it is so arranged that the engine can be started by either cylinder. Steam from the main header enters through a 12-in. pipe to a separator, which is piped to the high-pressure cylinder.

Between the throttle valve and the separator a 12-in. pipe branches out and is connected to the 14-in. exhaust pipe between the receiver and a valve placed close to the exhaust side of the high-pressure cylinder. At the other end of the receiver a 14-in. pipe is connected to the low-pressure cylinder with a valve between the two. The 24-in. low-pressure exhaust is fitted with a valve between the cylinder and branches in the pipe, one of which leads vertically to the atmosphere and is fitted with a back-pressure valve, while the other connects to a horizontal feed-water heater, which is between the cylinder and the jet condenser. From the bottom of the receiver, which is at the rear and between the high- and low-pressure cylinders, a 14-in. pipe connects to the low-pressure exhaust line between the valve and the point where the branch occurs.

In case either cylinder or side of the engine is disabled, the other side can be operated as a simple engine and run either condensing or noncondensing. For instance, if the high-pressure side is disabled, it is only necessary to close the valve on both sides and admit steam to the receiver though the valve in the 12-in. bypass.

If the low-pressure side is out of order, the valve between the receiver and the cylinder is closed, and the valve in the exhaust pipe and that in the 12-in. low-pressure bypass opened. The high-pressure cylinder then exhausts in the regular way to the receiver, through the bypass and either to the atmosphere or to the condenser.

The feed-water heater raises the temperature of the feed water to 90 deg. and is forced by power pumps through the economizer, where the temperature is increased but 95 deg.; the reason will be explained further on.

When additions to the mill were made, the vertical engine became overloaded, and a second cross-compound horizontal unit of 1000 hp. capacity at 102 r.p.m. was

*"Power," June, 1889.

installed, Fig. 1, having 18 and 36 by 48-in. cylinders. This engine also exhausts to a jet condenser, but is not connected to a heater. Both of these engines are close to the boiler room, and therefore no great amount of condensation would be expected, even with saturated steam.

A still further extension of the mill necessitated another engine being installed 600 ft. from the boiler room. It is a horizontal cross-compound, of 1500 hp., running at 100 r.p.m., with 20 and 42 by 48-in. cylinders. The 7-in. steam main is suspended from beams in a storehouse by rod hangers with a bolt through the bottom of each, and on which a roller is hung, thus giving the pipe free movement.

It is in this pipe line that the benefit of the superheated steam is evidenced. In the engine room the pipe connects with a separator, the drip of which leads to a tilting trap, Fig. 2. During the writer's visit in the engine room the trap failed to discharge. When the cock on the top was opened it showed no water; dry steam only escaped.

The chief engineer and master mechanic, E. W. Trip, stated that after the engine is shut down, at least four hours elapses before the trap will tilt to discharge water of condensation. The dryness of the steam is attributed to the 25 deg. of superheat in the steam at the engine.

Boilers

There are two boiler rooms, which are separated by an economizer. In one there are two Heine water-tube boilers of 250-hp. rated capacity, equipped with superheaters which superheat the steam 125 deg. F. In the other boiler room there are nine 250-hp. boilers of the same make, but they do not have superheaters. These boilers are piped to the main header, where the saturated and superheated steam mingles and is carried to the several engines superheated at about 25 deg., at 150 lb. pressure.

The two boilers are operated under natural draft, but the nine boilers are worked with forced draft. The engine-driven blower is supported by a frame of I-beams at one end, and cross stringers; the outer ends of the stringers are supported by the boiler-room wall.

Fig. 3 shows the large battery of boilers. The discharge of the forced-draft fan is shown at the right. This air duct enters a square air main, 18x32 in. in size and which runs parallel with the boiler points. A 15-in. air pipe branches out of the main duct opposite each boiler and extends below the floor, where it turns at right angles and extends to the ashpit of the boiler to which it is to supply air. A maximum draft of 1 in. of water is automatically maintained when needed, the fan engine being equipped with a regulating valve.

The smoke flue for these boilers is 4½ ft. in diameter at the far end and increased gradually in size to 8 ft. where it connects with the economizer. Both sets of boilers are arranged to bypass the stack gases past the economizer by means of a series of dampers.

The chimney gases enter the economizer at a temperature of between 350 and 450 deg., according to the load on the boilers, and enter the 178-ft. chimney at 205 deg. The chimney is 13 ft. inside diameter at the top. The feed water is heated from 90 deg., at which temperature it leaves the heater, to 185 deg. upon leaving the economizer. This slight increase in temperature is due, of course, to the low temperature of the flue gases, which is the result of the manner of arranging the boiler baffling.

The idea is simple, that of removing the last row of brick from the lower baffle at the back end of the tubes, and the addition of one length of bricks to the top baffle at the front end of the tubes. This enlarges the area of the opening to the first pass of tubes and restricts the area from the other end. The result is that exceptionally good combustion occurs in the furnace and combustion chamber.

Looking into the rear end of the boiler furnace shows this to be so, as there is but slight indication of smoke and the temperature of the flue gases indicates that the boiler-heating surface is absorbing a high percentage of the heat. It is explained by the engineers that restricting the free escape of the heated gases gives them an opportunity to ignite before the temperature is lowered by coming in contact with the comparatively cold surface of the boiler tubes.

Fig. 3. Boiler Room Containing Nine Water-Tube Boilers. The Forced-Draft Fan Is Supported above the Firing Aisle on Girders

Only 8 Per Cent. of Graduating Engineers Enter Other Fields—The statement that graduates of engineering schools do not follow the engineering profession is shown to be erroneous in the case of the College of Engineering of the University of Illinois. Data recently collected show that of the 2165 graduates, 1933, or 89 per cent., are engaged in one way or another in engineering work, and that only 173, or about 8 per cent., have gone into other fields. The occupations of the graduates of the College of Engineering are tabulated as follows:

		No.	Percentage
A—Nonengineering:			
1	Farmers and ranchmen	52	2.39
2	Merchants	31	1.42
3	Executive officers of mercantile companies	19	0.88
4	Editors	19	0.88
5	Real estate and insurance	15	0.68
6	Salesmen	10	0.46
7	Army officers	8	0.36
8	Bankers	6	0.28
9	Physicians	5	0.24
10	Lawyers	5	0.24
11	Miscellaneous	3	0.13
	Total	173	7.96
B—Engineering:			
1	Employees of engineering companies	1370	63.2
2	Architects	318	14.6
3	Executive officers of engineering companies	130	6
4	Teachers	95	4.6
5	Consulting engineers	20	0.92
	Total	1933	89.32
	Deceased	59	2.72
	Grand total	2165	100.00

Fixing the Decimal Point in Slide-Rule Calculations*

By Charles G. Richardson

Not long ago the slide rule was frequently held up to ridicule, especially by those who could not or would not use it. It was termed a "guess-stick," and an error by the manipulator was hailed with satisfaction. This feeling now has given place to one of respect for its value as a great time and energy saver in mechanical calculations, but the idea seems to prevail that to acquire skill with the rule one needs unusual mental equipment. In the writer's opinion, the inexcusably opaque "instruction" books which have been distributed with slide rules are in a great measure responsible for these conditions. Another feature of the slide rule which has discouraged beginners and generally limited its use is the determination of the position of the decimal point. Some eight years ago the writer devised a method of locating the decimal point in slide-rule calculations which is extremely simple and which can be applied to any combinations of multiplication and division. Bearing in mind that when the words "left-hand figures" are used *the number of figures to the left of the decimal point* (or in the integral portion of the number) is meant, there are two short rules which must be thoroughly memorized as follows:

Rule No. 1. Multiplication—The left-hand figures in the product equal the sum of the left-hand figures in the factors, except that one left-hand figure must be subtracted for each time the slide projects to the right.

Rule No. 2. Division—The left-hand figures in the quotient equal the left-hand figures in the dividend minus the left-hand figures in the divisor, except that one left-hand figure must be added to those in the dividend for each time the slide projects to the right.

These two rules embody the whole method, and once having been learned there only remains their application. *Note that no reference is made to slide projections to the left.*

The number of "left-hand figures" would be

3 in	954.210
2 in	53.198
1 in	5.733
0 in	0.534
—1 in	0.014
—2 in	0.004

The use of the two rules will now be illustrated by examples chosen at random, leading from simple problems to those more complex. The calculations are given in detail, but after a little practice the decimal point can be determined mentally with rapidity. It is understood that the lower scales *C* and *D* on the rule are used.

Example:

$$7 \times 5 = 35$$

The slide does not project to the right; therefore add the left-hand figures of the factors, giving two in the product.

Example:

$$8.5 \times 6 \times 12 = 612$$

The slide projects once to the right; therefore add left-hand figures of factors and subtract 1, giving three units in the product.

Example:

$$8 \times 6 \times 12 \times 0.13 \times 0.075 = 5.62$$

The slide projects twice to the right; therefore $(1 + 1 + 2 + 0 - 1) - 2 = 1$ left-hand figure in the product.

Example:

$$\frac{150}{25} = 6$$

The slide does not project to the right; therefore subtract the divisor's left-hand figures from the dividend's, or $3 - 2 = 1$ figure in the quotient.

Example:

$$\frac{380}{25} = 15.2$$

The slide projects once to the right; therefore add 1 to the dividend's left-hand figures and then subtract the divisor's, or $(3 + 1) - 2 = 2$ left-hand figures in the quotient.

Example:

$$\frac{4800}{24 \times 16} = 12.5$$

The slide projects twice to the right; therefore $(4 + 2) - (2 + 2) = 2$ left-hand figures in the quotient.

In formulas involving a combination of multiplication and division the value of the method especially asserts itself. For instance, the slide-rule lesson in the Study Course (Feb. 10, p. 211) gives the following example:

$$\frac{605 \times 921}{437} = 1275$$

First dividing, then multiplying, gives one projection of the slide to the right in division, or adding one to the dividend's left-hand figures and subtracting the divisor's we obtain $(3 + 3 + 1) - 3 = 4$ left-hand figures in the result. The Course states that it is clear that the answer "is a whole number and there is no decimal point to be placed." It seems to the writer, however, that it is not at all clear *how many* places there are in the whole number as compared with the simple method of locating the decimal point just described.

When a projection to the right in division is followed by a projection to the right in multiplication, the corrections balance each other since the former adds one and the latter subtracts one from the left-hand figures in the dividend, and hence both may be disregarded. For instance, another Study Course problem (Feb. 24, p. 283) is

$$\frac{0.492 \times 1.29}{33.4} = 0.019$$

in which the author, after performing the slide-rule manipulations, says, "Now to locate the decimal point. Inspection of the numerator shows it to be approximately 0.5 and 33 will not go into it until it is multiplied by 100 or the decimal point moved two places to the right. The first figure in the answer will, therefore, come in the second place after the decimal point, or 0.019 is the answer." How much simpler to observe that the slide projects to the right once in division and once in multiplication forming a balance, or $(0 + 1) - 2 = -1$; or there is a cipher before the first figure in the answer.

*See also "To Find the Number of Integer Places in a Product or Quotient," "Power," Mar. 24, 1914, page 400.

Example:

$$\frac{17 \times 14 \times 24}{32 \times 68 \times 0.81} = 3.24$$

Here we have one projection to the right in multiplication but none in division, and consequently $(2 + 2 + 2 - 1) - (2 + 2 + 0) = 1$ left-hand figure in the result.

As we proceed to longer examples it may be difficult to separate *mentally* the number of projections to the right in multiplication from those in division. Short vertical lines may be used to keep this score, these marks being placed either above or below the division line, depending upon whether the operation is one of multiplication or of division. When a projection to the right in division is immediately balanced by a projection to the right in multiplication by moving the runner to the next number in the dividend, no score is necessary. To illustrate:

$$\text{Score: } \frac{/}{//} \frac{118 \times 230 \times 1.96 \times 0.00062 \times 186}{194 \times 0.063 \times 68 \times 0.13 \times 15 \times 12.5} = 0.302$$

Taking the solution step by step

118 ÷ 194	slide is to left (disregard)
Multiply by 230	slide is to left (disregard)
Divide by 0.063	slide is to left (disregard)
Multiply by 1.96	slide is to right (score above line)
Divide by 68	slide is to left (disregard)
Multiply by 0.00062	slide is to left (disregard)
Divide by 0.13	slide is to right (balance—disregard)
Multiply by 186	slide is to right (balance—disregard)
Divide by 15	slide is to right (score below line)
Divide by 12.5	slide is to right (score below line)

Now the excess of the lower score over the upper is 1; therefore the slide has gone once more to the right in division than in multiplication; hence 1 is to be added to the dividend's left-hand figures before subtracting the divisor's. It makes no difference in what order the problem is solved, the *excess* of one group of projections to the right over the other group will be the same.

Eight years of daily use of the method in a department requiring calculations of considerable complexity has thoroughly demonstrated its value in promoting accuracy and rapidity.

Central Stations and Independent Plants

By W. H. Booth

There are places where it is cheaper to buy current from some central station than it is to make it for oneself. A central-station man is usually adept at showing that private plants are costing much more to their owners than purchased current, but there is no good reason why a private plant should be so much less economical to work. Each case must be taken upon its merits and only general views can be taken in a discussion. In favor of the central station it is usual to claim that fuel, stores, oil, etc., can be bought for minimum prices and that wages are less per unit of current. When a central-station man compares costs he includes on both sides the capital cost of the space occupied and the proper share of the wages to be debited against current. Now good and particular accounting is all very well in its proper place, but this sort of accounting is often merely of an academic character and if carried too far may result in loss.

In the erection of buildings certain foundations are necessary and these result in basements and sub-basements which involve capital cost and are not available for the uses to which daylight floors may be put. This capital cost being an essential part of a building and not having a letting value, or a use value other than for a power plant, is not properly chargeable against the cost of current. For, if by adding this charge, the owner is made to appear to be a gainer by the purchase of outside current, he will still remain liable to pay the interest on the capital expended on the useless part of the building. Again, if he must install steam heat and therefore pay for boilers, the cost of such boilers can only be debited against current in so far as it has been made greater for the sake of higher pressure for engine working. And if fuel must be used for the steam heating and this heating happens to use all the exhaust steam from the power plant, can it be fair to charge the power plant with more of the fuel cost than is represented by the small fraction of the heat converted into work and that lost by radiation from the power plant? And so with labor costs. If there must be a staff of two men without a power plant, and the same two men can do the work with the power plant, this charge cannot be debited to current when it becomes a question of deciding on the true cost. In short, the accounting for this purpose must show simply how much more or less the owner will pay on the whole building, plant and men and materials when he has and when he has not a power plant installed.

In a private plant all turns on the man in charge. A good man will run a so called obsolete plant with better results than the central station will sometimes get out of the so called best plant. One hears and reads much today about top-notch plants and efficiency. But the high records of top-notch plants are obtained very much by engineering accounting on the lines above indicated. An engine is using so much steam per horsepower-hour, as shown by the Lea recorder, but this instrument is not meant to be used other than its location warrants. It does not show heat losses in steam pipes, or at the boilers. It is possible, with a small staff, to run a low-pressure plant in good order and to save money as compared with the overall costs of a top-notch plant.

In England it is certainly a fact that the methods of charging for current have been developed on the academical view of what a user should pay. The utmost indignation is felt at the idea that a small consumer should use what he does use during one hour only per day. It is pointed out how to supply him with that one unit-hour, there is $100 of plant at the station and that he uses it only one hour out of 24. Before he can be supplied he must pay interest on the 23 hr. This righteous and furious attitude is adopted toward any number of small users, the while papers are being read on diversity factors and all manner of other academic matters. The charging faddists have rendered any attempt at a diversity factor

impossible. Because one man uses current only from 9 to 10 a.m. all other small users apparently use current only from 9 to 10 a.m.

The attitude of the electrical supplymen has been one of antagonism to the user, based on the difficulty of economical storage of electricity. The central-station man adopts a similar attitude toward the private plant. There is, of course, a limit below which a plant may be more costly than to purchase current. It would often be so in this country but for the systems of charging. Thus current is sold for 2c. per unit. This sounds very nice, but it is loaded up with an unwarrantable charge per quarter upon each rated horsepower of the motor. Thus, if to be liberal, a 5-hp. motor be put in to drive a 1½-hp. water pump, which will not take 3 hp. of current, the motor will be taxed nearly $10 per quarter and the cost of current runs up to many times 2c. per unit.

Where uncontrolled by an engineer, contractors are apt to put in excessive motors, and so it comes that power users are actually taxed on a few figures stamped on a nameplate. This is particularly unfair with a well-pump motor, for the work always remains constant and the maximum and excess power of the motor is never used.

All this is excellent as a means of squeezing dollars out of a user of current, but it is not good business and is only a way of making known as one client put it, that "the supply company will have you anyhow" and so he insisted on steam power.

Private water-supply systems are used very much in London, because the charge for public water is made 5 per cent. on the rental value of the building. Now a large building, housing at most, say, 500 or 1000 people, will only consume a few thousand gallons of water per day. By meter such would cost $1 down to 75c. per day or less, but on the assessed value the water charge may be $4 upward per day. A private supply may cost 30c. per day in interest and from nothing to 4c. per 1000 gal. to pump. With electric power, which is the nicest drive, the pump runs only when the water level drops a certain distance in the roof tank and it then runs until the tank fills—all according to the setting of the automatic switch and float. The taxes on motor rating compel or induce owners to consider steam power, drives off the hydraulic-pressure mains or gas power, none of which are so simple or occupy less space than the electric drive with a worm gear direct on the pump shaft.

Were the nation as a whole efficiently organized for economy it would not be possible that such a state of affairs could prevail. There is first the tussle between the public supply of water and the owners' right to tap the deep, pure water under his feet. Next there are the several systems of driving the pump and for every case he meets a contractor is apt to push one more than another irrespective of conditions. Out of five taken at random, two are electrical, one is gas driven, one steam driven and one has a 33-lb. natural-pressure head and needs no pumping. In each case the best has been done for the given conditions.

Nobody can declare offhand as a general proposition for or against independent supply of water or electricity. And in no case can the question be decided by what some men call a fair and proper allocation of costs. Practical men know this.

I once knew a man who had a good business which was departmentalized. In addition to selling departmental products there was a department for assembling parts and selling a finished product. To this department all material was charged at full profit rates and at the end of the year this department showed a small profit on its turnover. It had, however, enabled the other departments to sell parts at a profit and it had done its share in paying overhead charges. It was, in short, producing a profit inside the four walls. The owner shut it down as a loss. He was a victim of academic accounting.

Power Plant of the Boston Opera House

SYNOPSIS—An isolated plant with marine water-tube boilers and direct-connected generator and engine units. Special attention having been given to preventing vibration, it was eliminated by insulating the foundations from the building proper.

The disagreeable feature of vibration is manifest in many buildings where no attempt has been made to prevent it. Although the engines may be in the basement, far from the tenants, all feel the vibration of the engines more or less. This disagreeable feature is avoidable in most cases with but little additional expense, and attention to it will result to the satisfaction of all.

In the case of a place of amusement, one can easily

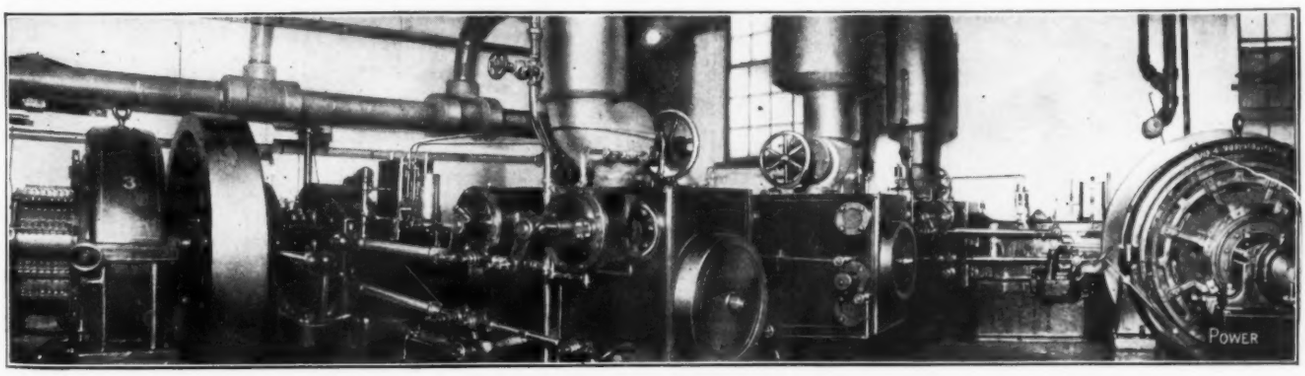


FIG. 1. THREE 14x22-IN. FOUR-VALVE ENGINE-GENERATOR UNITS, BOSTON OPERA HOUSE

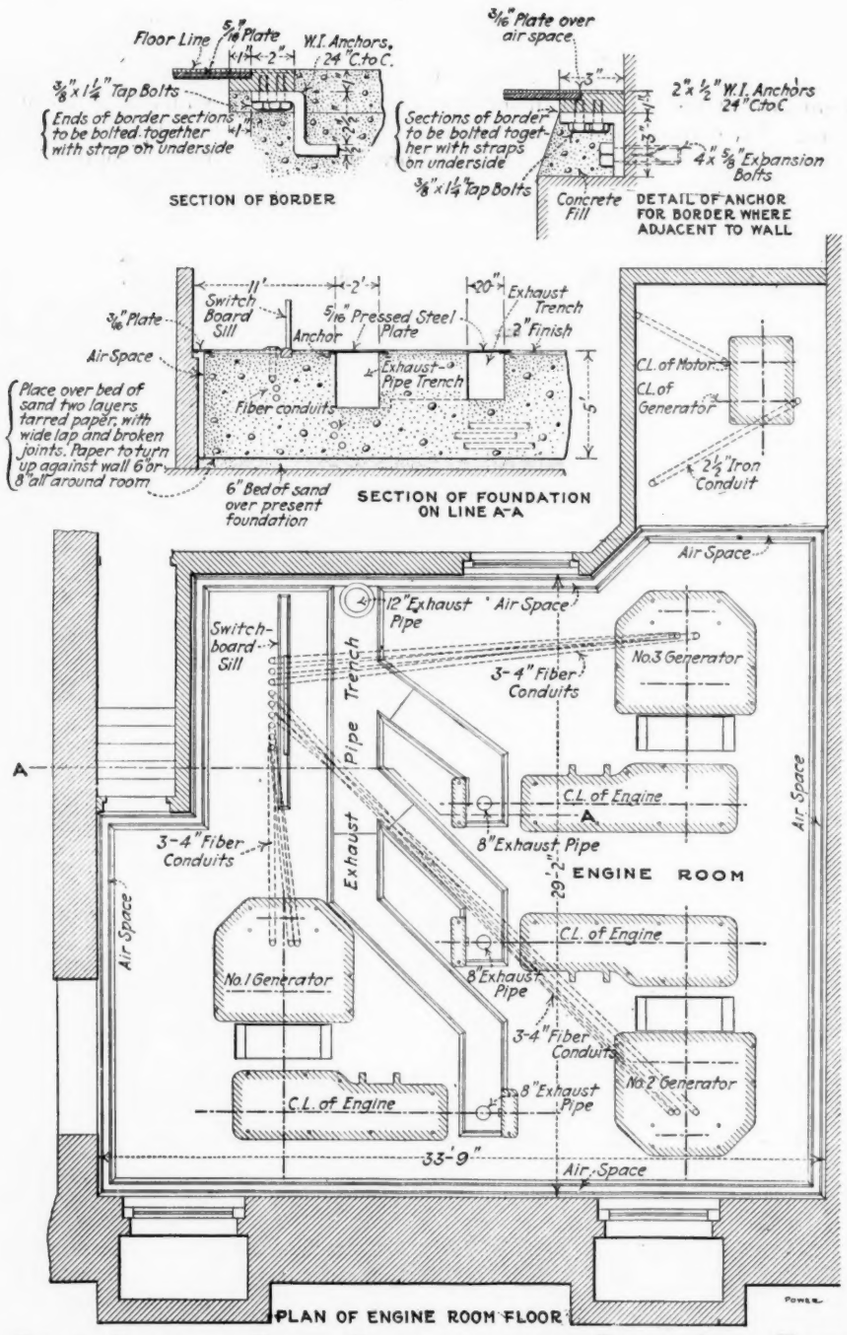

Floor Line
5/16" Plate
W.I. Anchors, 24" C. to C.
3/8" x 1 1/4" Tap Bolts
Ends of border sections to be bolted together with strap on underside
SECTION OF BORDER
3/16" Plate over air space
2" x 1/2" W.I. Anchors 24" C to C
Sections of border to be bolted together with straps on underside
4 x 5/8" Expansion Bolts
3/8" x 1 1/4" Tap Bolts
Concrete Fill
DETAIL OF ANCHOR FOR BORDER WHERE ADJACENT TO WALL
Switch Board Sill
Anchor
5/16" Pressed Steel Plate
Exhaust Trench
2" Finish
3/16" Plate
Air Space
Exhaust Pipe Trench
Fiber conduits
Place over bed of sand two layers tarred paper, with wide lap and broken joints. Paper to turn up against wall 6 or 8" all around room
6" Bed of sand over present foundation
SECTION OF FOUNDATION ON LINE A-A
C.L. of Motor
C.L. of Generator
2 1/2" Iron Conduit
Air Space
12" Exhaust Pipe
Switch-board Sill
Pipe Trench
3-4" Fiber Conduits
No. 3 Generator
C.L. of Engine
8" Exhaust Pipe
ENGINE ROOM
Exhaust
29'-2"
No. 1 Generator
No. 2 Generator
33'-9"
PLAN OF ENGINE ROOM FLOOR

FIG. 2. DETAILS OF ENGINE FOUNDATION AT THE BOSTON OPERA HOUSE

realize the annoyance caused by the constant jars of vibration sent to every part of the house, both to the audience and to the performers. When the Boston Opera House was built, this discordant feature was given consideration. The engine foundations are separated from every part of the building by air spaces, thus vibration has been eliminated.

In the engine room there are three 14x22-in. Ball four-valve engines, directly connected to three Westinghouse 125-kw., 125-volt generators, at 200 r.p.m., Fig. 1. These units have separate foundations constructed as shown in Fig. 2. First spiles were driven and the spaces between them filled with concrete. On this a 6-in. layer of sand was placed, being covered by two layers of tarred paper with wide lap and broken joints. The paper is turned up against the wall about 7 in. all around the room; on this the concrete foundations rest. They are 5 ft. thick and are provided with trenches for the exhaust pipe and conduits for the generator cables running to the switchboard. A 4-in. air space is provided between the foundation and the walls of the building.

The engine-room walls are built with a shelf to which 2x½-in. wrought-iron angles are secured by 4x⅝-in. expansion bolts. On the foundation side, angle irons are imbedded in the concrete, and metal-border strips rest on the two sets of irons, coming a little below the level of the floor. The ⅝-in. pressed-steel floor plates over the air spaces are fitted to the side strips, which are planed to such a depth that the plates come even with the engine-room floor.

In addition to the main generating units, there is a 25-kw., motor-driven, 125-volt generating set for use when all of the engine-driven sets are idle. Central-station current is used on this unit.

The main steam header is 10 in. in diameter and is supported by vertical pipe stands imbedded in the foundation. On the top end is a roller to allow for the movement of the pipe line. By this arrangement the header is not attached to any part of the building and there are no ill effects from vibration. A 6-in. lead branches from the top of the 10-in. header for each engine. The exhaust pipes run in a trough in the foundation to an open heater in the boiler room.

Steam is generated in two 250-hp. Worthington water-tube boilers. They are hand fired and carry a pressure of 125 lb.

Boiler-feed water is obtained from either of two 7½ and 5 by 6-in. duplex pumps. There is also a vertical sump pump driven by a 1-hp. motor. It is automatic in action, the height

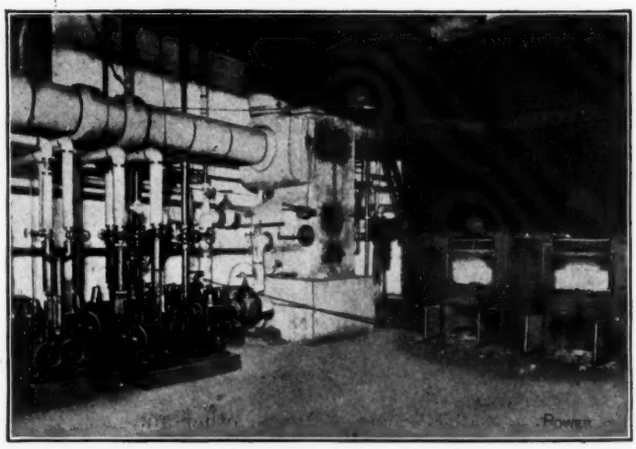


FIG. 3. ONE OF THE BOILERS AND THE STEAM PUMPS

of water in the sump starting or stopping the motor by means of a float and a weighted double-throw switch. All of these pumps are in the boiler room. Attached to the wall is a vertical 9½ and 9½ by 10-in. air pump used for elevating the stage and operating the drip curtains.

Coal is delivered from wagons through a manhole to the hopper of a motor-driven belt conveyor and is discharged into a storage room adjoining the boiler room. It is wheeled in for use as desired. In the winter during cold snaps, when the coal is frozen, it is found advisable to break the lumps to prevent stoppage in the hopper.

Synchronous Converters and Their Operation--I

By Eric A. Lof*

SYNOPSIS—The general characteristics of synchronous rotary converters, the voltage and current ratios and methods of regulation. A second installment will cover their operation.

The synchronous converter is the most generally used machine for converting alternating into direct current, and *vice versa*. Mechanically, it is similar to a direct-current generator to which have been added collector rings and their connections to the armature winding. Electrically, however, it is quite different, and, although in its relation to the alternating-current supply it acts as a synchronous motor and to the direct-current circuit

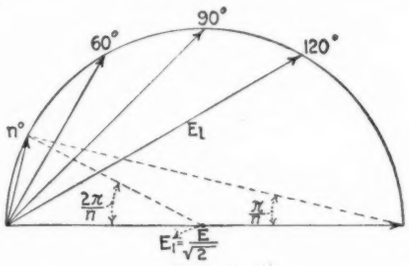


Fig. 1.

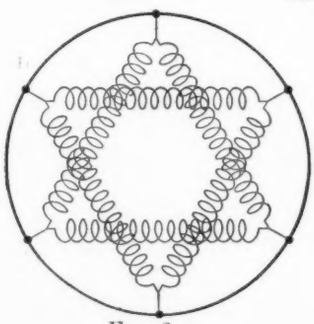


Fig. 2.

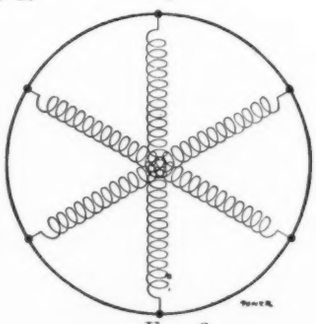


Fig. 3.

as a direct-current generator, it is essentially different from these machines so far as the armature reaction and heating effect of the armature currents are concerned.

The torque produced by the alternating current, and consumed by the direct current, is applied at the same conductors; consequently there is no transfer of mechanical energy, and the machine structure can be made smaller than a direct-current generator of the same rating. The current actually flowing in the winding is made up of the difference in instantaneous values of the variable alternating current and the constant direct current. These partly neutralize each other and the current actually flowing is much less than would otherwise be the case, resulting in a reduced copper loss.

Voltage Ratio

The theoretical voltage ratio of a converter is readily determined. In single-phase machines the two collector rings are connected to armature conductors with the same angular distance apart as the commutator bars under adjacent sets of brushes, and

$$E_1 = \frac{E}{\sqrt{2}}$$

where

E_1 = Effective value of the alternating e.m.f.;
E = Direct current e.m.f.

Representing the effective e.m.f. between the collector rings of a two-ring, single-phase converter by the diameter of the circle in Fig. 1, the effective e.m.f. E_1, between adjacent rings of a converter having n rings may be represented by that chord which subtends an angle of $\frac{360°}{n}$ or $\frac{2\pi}{n}$. That is,

$$E_1 = \frac{E}{\sqrt{2}} = sin\,\frac{180°}{n}$$

which gives:

For single phase

$$E_1 = \frac{E}{\sqrt{2}} = 0.707\,E$$

For three phase

$$E_1 = \frac{\sqrt{3}\,E}{2\sqrt{2}} = 0.612\,E$$

Quarter-Phase. This converter generally has each phase of the supply circuit connected to diametrically opposite points of the armature winding, and the ratio equals that of the two-ring single-phase converter, or

$$E_1 = \frac{E}{\sqrt{2}} = 0.707\,E$$

Six-Phase. Two different connections are used with this type, the "double-delta" and the "diametrical." With the former, Fig. 2, the voltage ratio is the same as for the three-phase converter, the connection simply consisting of two delta systems. With the diametrical connection, Fig. 3, the ratio is the same as for the single-phase converter, it being similar to three such systems. Therefore, for six-phase, double-delta.

$$E_1 = \frac{\sqrt{3}\,E}{2\sqrt{2}} = 0.612\,E$$

For six-phase, diametrical.

*Electrical engineer, General Electric Co., Schenectady, N. Y.

$$E_1 = \frac{E}{\sqrt{2}} = 0.707\ E$$

With six-phase converters, the transformers can also be connected in "double-star," in which case the ratio between the phase voltage and the direct voltage will be the same as for the "double-delta" connection. The ratio of the effective e.m.f. E_0, between any collector ring and the neutral point is always

$$E_0 = \frac{E}{2\sqrt{2}} = 0.354\ E$$

The foregoing ratios are only theoretical, the actual values differing somewhat, depending upon: The wave shape of the impressed e.m.f.—that is, the ratio of the potential, as read by a voltmeter, to the maximum instantaneous value of the wave; the construction of the machine, especially the ratio of the pole arc to the pole pitch; the resistance of the armature winding causing a drop of potential in the armature as well as in the brushes under load; the operating conditions—that is, the brush position, the field excitation and whether the converter is used to change from alternating to direct current or *vice versa*.

The direct e.m.f. bears a definite relation only to the maximum value of the alternating e.m.f. and to the effective value only insofar as the latter depends on the former. Therefore, with a flat-topped impressed e.m.f. wave, the maximum value and the direct e.m.f. depending thereupon, will be lower than with a sine wave of the same effective value, while with a peaked impressed wave they will be higher.

The ratio of pole arc to pole pitch is also an important factor influencing the voltage relation. By altering this ratio the curve of flux distribution is changed; hence also the ratio between the maximum and effective values of the induced alternating e.m.f.

When converting from alternating to direct current, the voltage at the commutator brushes is less than the generated direct e.m.f. and the counter generated alternating e.m.f. is less than the impressed, due to the resistance drop in the armature and brushes. The armature self-induction has little effect if the current is in phase with the impressed e.m.f. If the current is lagging, however, the counter generated alternating e.m.f. is reduced below the impressed and, if leading, it is increased. Thus the direct voltage will decrease with increased load and decreased excitation (lag), but increase with increased excitation (lead).

For inverted converters the alternating voltage is decreased with increased load, especially load of lagging current, and is increased with leading current. The excitation, however, has no direct effect on the ratio, but decreased excitation increases the speed and thus the frequency, and inversely, except when the frequency is fixed by parallel operation with an alternating-current system of fixed frequency. In the latter case, a change of excitation simply changes the current phase, and with it the ratio.

From the foregoing it follows that it is impossible to give a value for the actual voltage ratio which will apply to different types of converters. In general, however, the following values may be taken as approximately correct.

RATIO A. C. TO D. C. VOLTAGE

Phase Connection	No Load		Full Load		Inverted Full Load	
	Cycles		Cycles		Cycles	
	25	60	25	60	25	60
Single-phase, quarter-phase and six-phase diametrical	0.71	0.72	0.72	0.73	0.69	0.70
Three-phase and six-phase double-delta	0.61	0.62	0.62	0.63	0.60	0.61

Voltage

The direct voltage generally used is 275 volts for power and lighting work, while for railway work, the standard voltage has been 600. During the past few years, however, a potential of 1200 volts has become a recognized standard for interurban lines, while 1500 volts is as yet more in the nature of a special voltage for those cases where the saving in copper offers sufficient advantage.

Current Ratio

The ratio between the direct current I and the effective value of the alternating current I_1, entering at the collector rings, is subject to greater variation than the voltage ratio. This, however, is not of great importance from an operating standpoint, as it is only necessary to know the current ratios in connection with the armature heating, which determines the rating of the converter, and for this purpose an approximate value is sufficient.

Neglecting the losses in the machine, and assuming the impressed and induced alternating e.m.f. to be in phase, the output from the direct-current side must equal the input to the alternating-current side. Let

E = Direct e.m.f.;
E_1 = Effective value of alternating e.m.f.;
I = Direct current in line;
I_1 = Effective value of alternating current in line;
I_a = Effective value of alternating current in winding;
n = Number of rings.

For a single-phase converter

$$E_1\ I_1 = E\ I$$

but

$$E_1 = \frac{E}{\sqrt{2}}$$

whence

$$I_1 = \sqrt{2}\ I = 1.414\ I$$

In general for converter with n-rings

$$I_1 = \frac{2\sqrt{2}\ I}{n}$$

The current in the windings is obtained from the formula

$$I_a = \frac{\sqrt{2}\ I}{n\ sin\ \frac{180^\circ}{n}}$$

The following table shows the approximate current ratios in a convenient form:

APPROXIMATE CURRENT RATIOS, ALTERNATING TO DIRECT

Phase Connection	Effective Line Currents	Effective Currents in Winding
Single-phase	1.414	0.707
Three-phase	0.943	0.545
Quarter-phase	0.707	0.5
Six-phase	0.472	0.472

Heating and Capacity

The rating of a synchronous converter is generally determined by the heating and commutation. It can, as a rule, be comparatively expressed in terms of the rating

which the same machine would have if operated as a direct-current generator. The following tabulation gives the output at unity power factor of different types of synchronous converters with the same heating that would take place if the converters were operated as direct-current generators, the losses being neglected for simplicity:

COMPARATIVE CAPACITIES OF SYNCHRONOUS CONVERTERS ON BASIS OF AVERAGE HEATING AT UNITY POWER FACTOR

Direct-current generator	100
Single-phase converter	85
Three-phase converter	134
Quarter-phase converter	164
Six-phase converter	196
Twelve-phase converter	224

It is seen from the above that the more points at which the winding of a converter is tapped, the more direct is the path from the collector rings to the commutator, and the less is the heating of the armature conductors. These can, therefore, be of smaller cross-section than in a direct-current generator of the same capacity and, consequently, the greater the number of phases, the greater is the capacity of a synchronous converter as compared with a generator or motor. A considerable gain is made by changing from three-phase to six-phase, but relatively little economy is obtained by still further increasing the number of phases.

The standard temperature rise guarantees at the present time for sychronous converters, except for the smallest sizes, are 35 deg. C. (95 deg. F.) for continuous full load at unity power factor, and 55 deg. C. (132 deg. F.) for two hours, with 50 per cent. overload at unity power factor. Occasionally a 5-deg. higher temperature is allowed for the collector rings and the commutator. These guarantees are based on a room temperature of 25 deg. C. (77 deg. F.) and correction for differences therefrom are made in accordance with the rules of the American Institute of Electrical Engineers.

Converters are now built in sizes up to 2500 kw. for 60 cycles and 4000 kw. for 25 cycles.

Frequency

Twenty-five and 60 cycles are the two standard frequencies in this country, the former principally in connection with railway and power service and the latter for lighting. The converter being a synchronous machine, the frequency must have a fixed relation to the speed and the number of poles, from which it follows that the peripheral speed of the armature and commutator increases with the frequency. The peripheral speed of the commutator is limited both by mechanical and electrical considerations.

The present reliability of the 60-cycle converter is due principally to the improvements in mechanical design. With the ability to build longer high-speed commutators, it became possible to increase the speed and thus the output per pole. In recent machines the output per pole has been increased beyond the inherent commutating ability, and commutating poles have been adopted.

Voltage Variation

It is often necessary to vary the direct-current voltage over a considerable range. Such a variation, however, cannot be made by simply varying the field strength as in the ordinary direct-current generator. Therefore, it is necessary to provide means for changing the applied alternating voltage, which can be accomplished in a number of ways.

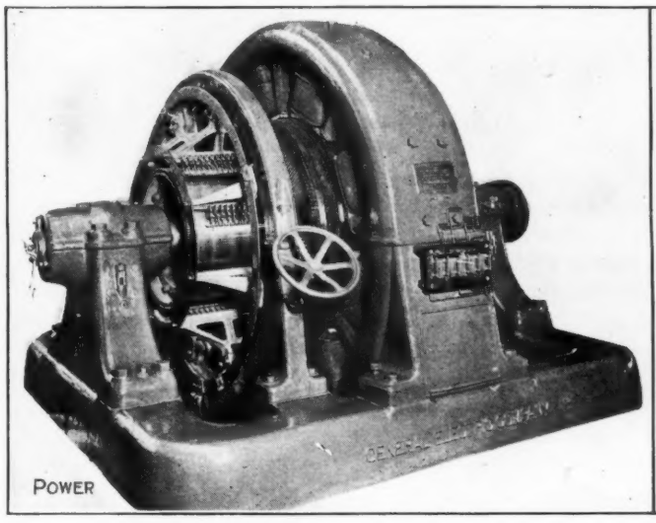


Fig. 4. Regulating-Pole Converter, 750-Kw., $^{240}/_{300}$ Volts

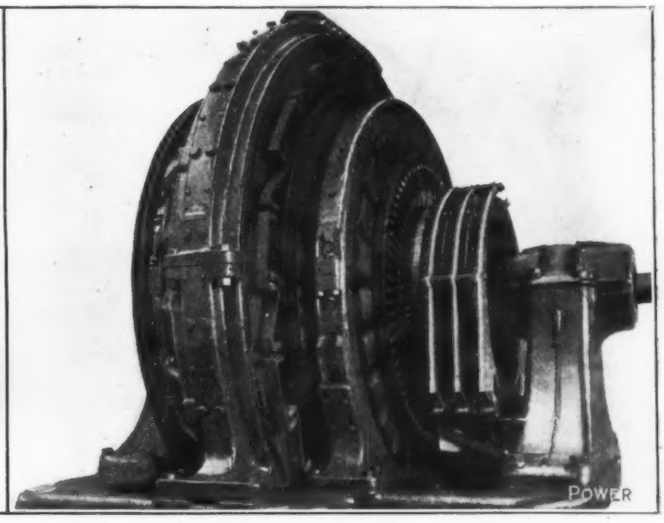


Fig. 5. Synchronous Booster-Converter, 3500-Kw., $^{240}/_{310}$ Volts

Transformer Taps: This method consists in the use of quick-acting switches connected to the taps of the transformers. Such a mechanism, however, is complicated and the arcing is apt to start short-circuits; hence it is seldom used.

Shunt-Wound Converter with Induction Regulator: A much better method is the use of an induction regulator between the terminals of the transformer secondary terminals and the synchronous converter. This avoids the necessity of any switching and gives a smooth variation in the supply voltage. The regulator consists of a movable primary winding, which is excited at constant alternating-current line voltage and induces practically constant voltage in the stationary secondary, connected in series with the line.* The voltage variation is obtained by turning the movable element through an angle, which changes the phase relation of the secondary voltage to the line voltage, to which it adds or subtracts vectorily. It is, therefore, possible to increase and de-

*See "Power," Dec. 30, 1913.

crease the line voltage by any amount up to the full secondary voltage of the regulator.

This method of control is generally used with shunt-wound converters in order to keep the voltage constant, when the line drop is excessive. The induction regulator is either hand-operated by means of a chain or motor drive, or the control can be made automatic by using a contact-making voltmeter and relay, which will automatically control the regulator motor.

Compound-Wound Converter with Reactance Coils: This method of voltage variation is based on the fact that an alternating current passing over an inductive circuit will decrease in potential if lagging, and increase if leading. As in the synchronous motor, a decrease in the field excitation will cause a synchronous converter to draw a lagging current from the line, and an increase in the field excitation a leading current. The total value of the current, however, will be increased, but the lagging and leading components do not represent any expenditure of energy, except that of the increased resistance loss in the conductors.

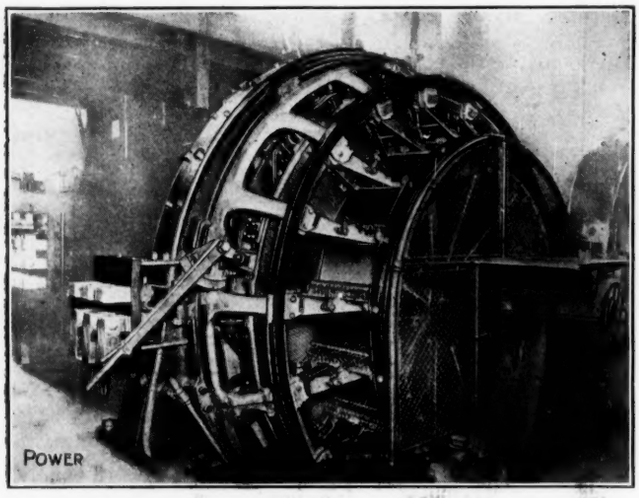


Fig. 6. 4000-Kw., 600-Volt, Commutating-Pole Rotary Converter

The excitation can be automatically regulated as the load comes on by providing the synchronous converter with a series field winding in addition to the shunt field. The inductance of the supply circuit and the step-down transformers, however, is frequently not sufficient to cause the required boost in the voltage, and in such a case it becomes necessary to insert reactance coils in the line or design the step-down transformers for extra high reactance. The lower the reactance, the greater must be the strength of the series field for the same regulation, and the larger is the lagging or leading current required. Inversely, too high reactance may lower the overload capacity of the converter. This method of voltage control is extensively used in railway work, where only a slight variation in the direct-current voltage is generally necessary.

Regulating-Pole Converters: This type offers a simple means of obtaining a variable direct-current voltage from a constant alternating-current voltage. It differs from a standard machine only in that the field structure is divided into two poles—a main pole and a small regulating pole. For normal voltage the main pole only is excited, while to raise or lower the direct voltage, the regulating pole is excited so as to either assist or oppose the effect of the main pole.

The regulating pole may be provided with either a shunt or a series field. When shunt wound, it may be controlled by a field rheostat either by hand or automatically, to hold a certain voltage or a certain load. Machines so equipped are particularly suited to constant-load service, but should not be used if required to carry light loads at the lower part of the voltage range, if they are to do so for periods much longer than is necessary for adjusting to the required voltage of the load before switching into service. At low voltage, the field for commutation is too strong for light loads, although excellent for heavier loads.

With series-wound regulating poles a great degree of overcompounding can be obtained with little change in the power factor. With the direction of rotation such that an armature conductor passes the regulating pole before the main pole, the machine will commutate almost the same as a commutating-pole machine.

Sometimes the regulating pole is provided with both a shunt and series winding. The former permits hand adjustment of the voltage for changes in service conditions.

Fig. 4 illustrates a synchronous converter of the regulating-pole type.

Series-Booster Converter: This consists of a standard synchronous converter and a series or booster alternating-current generator. The latter has the same number of poles as the converter, is mounted on the same shaft with it and is connected in series between the converter and the low-tension side of the transformers. There are two types of construction, the revolving-field type in which the booster is mounted on the outside of the collector end pillow block, and the revolving-armature type in which the booster is mounted between the collector rings and the armature winding of the converter, as shown in Fig. 5.

By varying or reversing the field excitation of this booster, the alternating voltage impressed on the converter proper can be increased or decreased as desired, the direct-current voltage delivered by the converter varying accordingly. By means of a reversing switch in the field circuit the polarity of the booster field may be reversed without opening the field circuit, and the generated voltage made either to "buck" or "boost" the voltage impressed at the collector rings.

Converters with Commutating Poles: The use of commutating poles on synchronous converters is comparatively new. With the addition of these poles the commutation may be so improved that the output per pole is nearly doubled. If the load is steady and uniform, it is evident that the limit of the design is caused by the heating. For fluctuating loads and with heavy overloads of short durations, such as in interurban-railway systems, steel mills, etc., the heating limit is eliminated. In other words, for the same kind of service, a smaller and lighter converter can be built, its rated load being correspondingly less and much nearer the average load.

The ampere-turns required by the commutating poles are much smaller than those required by a direct-current generator having an ordinary air gap. This is because the excitation of the commutating poles need only be sufficient to generate a counter e.m.f. equal to the reactive

voltage caused by a reversal of the load current of the coil while passing under a brush. It is unnecessary to provide additional excitation to cancel the armature reaction as in the case of a direct-current generator. Any disturbance tending to unbalance the usual alternating and direct-current relations would produce an armature reaction which would be a large percentage of the total excitation of the commutating poles and thus greatly affect the commutation. To prevent this it is advisable to increase the required excitation, which is done by using larger air gaps. Even then the sparking, when started from the alternating side, is quite severe, but this is overcome by providing a brush-lifting device, as shown in Fig. 6.

Two narrow brushes, one for each polarity, however, are allowed to remain on the commutator when starting so as to provide current for field excitation and to indicate the polarity. The sparking caused by these two pilot brushes is harmless, as they are very narrow, thus short-circuiting at a much lower voltage than would the main brushes.

As with the direct-current commutating-pole generator, an inductive shunt is also used. Its inductance is greater than the commutating field so as to accomplish the changes in the field strength more quickly. A greater percentage of the current will pass through the commutating-pole winding for increasing loads than at steady load, and for decreasing loads the commutating-pole current will be less than with the corresponding armature current at steady load. With a properly designed shunt, it is, therefore, possible to throw heavy overloads off or on, without creating a lag in the change of field strength behind the armature current sufficient to cause excessive sparking.

Inverted Synchronous Converters: Inverted synchronous converters while not used frequently are sometimes desirable, as in a low-tension direct-current system, where it is desired to supply an outlying district with direct current. This can be done by converting from direct to alternating current, transmitting as alternating, and then reconverting to direct current. Converters may also be used as a connecting link between alternating-current and direct-current generating systems so as to shift the load from one to the other, or inverted converters may be used simply to produce alternating current.

The speed of the machine when converting from alternating to direct current is fixed by the frequency and cannot be varied by altering its field excitation; this would merely change the power factor. However, when converting from direct to alternating current, the speed depends upon the field strength, being increased by a weak field and decreased by a strong field except when tied into an alternating-current system. It is evident, therefore, that there should be little or no series field on an inverted converter, or it will change in speed under load and deliver alternating current at variable frequency.

A lagging alternating current weakens the field, and thus increases the speed and frequency so that under certain conditions, as with an inductive load, the converter may reach a very high speed. Therefore, care should be taken to see that the field excitation is always large enough to prevent excessive speeds, especially when a second converter is operated from the inverted one to change back from alternating to direct current. Speed-limiting devices should always be furnished with synchronous converters used under these conditions. Separate excitation of inverted converters is also desirable, in which case the exciter should be mechanically driven from the converter. An increase in the speed will increase the exciter voltage and thereby the excitation of the converter, thus tending to check the speed.

Frequently, inverted converters are operated in parallel with alternators. In such cases, the danger of racing does not exist, if the generators and their prime movers are of such size that they cannot be carried away in speed by the converter. It is important, however, to investigate the speed regulation of the prime movers since the inverted converter runs at a uniform speed and if the alternators are not operating at constant speed, cross-currents will result.

The McMillan Smokeless Furnace

A new furnace of the dutch-oven type, designed to burn coal smokelessly, has recently been perfected by James McMillan & Co., 33 North Market St., Chicago. It is made up of a flat shaking grate, with inclined coking grates at either side, and a firebrick roof covered with asbestos and sheet metal.

Fig. 1. Front of McMillan Smokeless Furnace

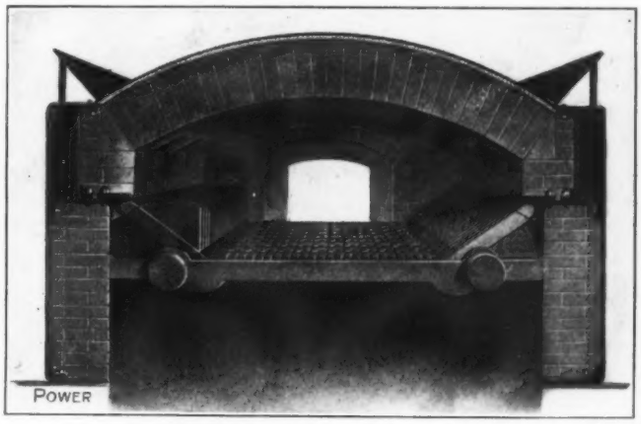


Fig. 2. View of Furnace from the Front

Fig. 1 shows the furnace front and Fig. 2 is a view looking into the rear of the furnace. From the latter

view the general arrangement will be evident. The furnace may be adapted to nearly every make of boiler for capacities ranging from 20 to 250 hp.

Coal is fed through the top of the furnace on either side, and is allowed to remain on the inclined coking grates until it has been freed of its volatile matter. Air, introduced through the perforated plates on the furnace front and admitted along the fuel bed, mixes with the gases distilled from the coal, and the mixture is burned without smoke as it passes over the incandescent coal on the horizontal grate. When the green coal has been thoroughly coked, it is shoved over on the flat grate by transfer bars fitted in the openings of the inclined grate. These bars are pivoted on a rod turned by the handle shown at the front of the furnace, and are curved at the outer end so that in any position they close the openings through which they project and prevent fine coal from falling through to the ashpit.

With this type of furnace there is no occasion to open the top door except for the removal of clinkers, so that the conditions are uniform and the drop in efficiency common to the usual hand-fired furnace during the firing interval is obviated. The air for the combustion of the coal on the horizontal shaking grate is supplied through the ashpit door as usual.

American-Ball, Four-Cylinder, Triple-Expansion Engine

A new high-speed engine for driving centrifugal pumps, built by the American Engine & Electric Co., Bound Brook, N. J., is of the triple-expansion type, with four cylinders. The illustrations show a 1000-hp. engine. The steam conditions for this unit were 250 lb. initial pressure and 25 in. vacuum. The engine is of the double-angle type. Fig. 1 shows how the two engine frames are bolted together and the small floor space required by a 1000-hp. engine.

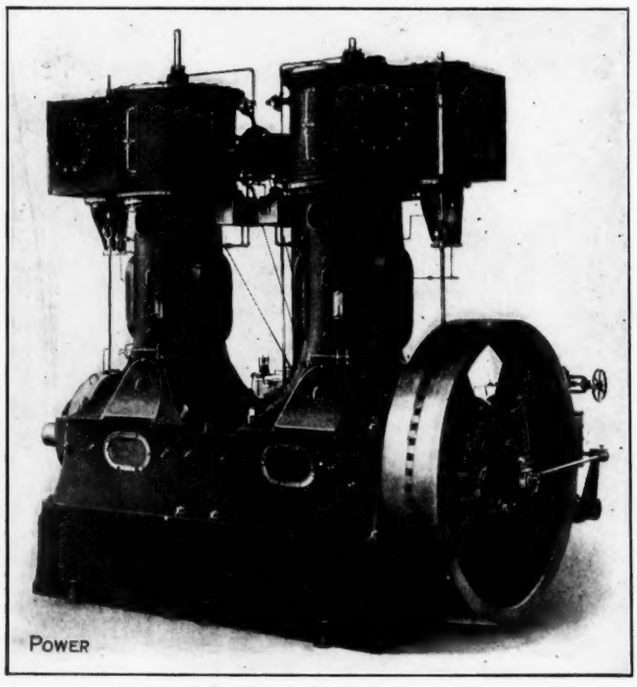


FIG. 1. REAR VIEW OF THE AMERICAN-BALL FOUR-CYLINDER ENGINE

The high-pressure cylinder is in the foreground, Fig. 2, the intermediate cylinder to the right; the low-pressure cylinders are vertical. This construction gives a large ratio of expansion and, therefore, high economy; it

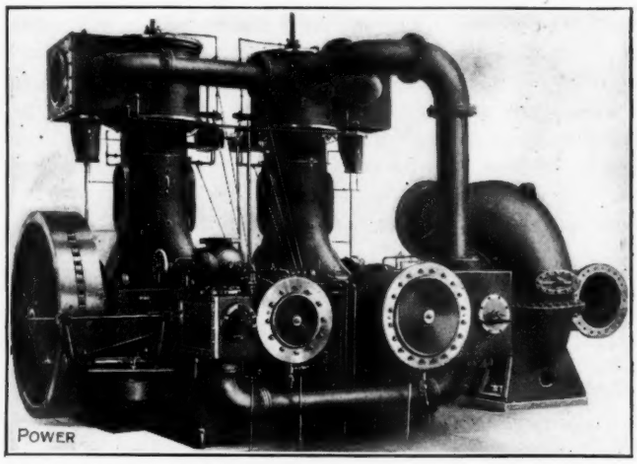


FIG. 2. FRONT VIEW OF AMERICAN BALL, FOUR-CYLINDER, TRIPLE-EXPANSION ENGINE

also eliminates a large low-pressure cylinder with its massive reciprocating parts. With a single large, low-pressure cylinder, the speed would have to be materially reduced, and this would increase the size, weight and space required by the engine. The increase in weight would in turn necessitate a decreased speed.

Higher speeds may be used with the four-cylinder construction because of the smaller size of the two low-pressure pistons and rods and as the inertia forces of the vertical reciprocating masses are opposed and balanced by equal and opposite forces from the horizontal cylinders. This advantage of the angle construction is now well known. The four-cylinder, triple-expansion engine is another application of the same design.

Vibration and pounding are eliminated, even at very high speeds, so that the foundations may be light and inexpensive. For stationary plants, a simple block of concrete is all that is necessary. For example, a 1000-hp., four-cylinder, triple-expansion engine would require about 25 cu.yd. of concrete for its foundation.

The design of the valves, pistons, crossheads, rods, etc., of these engines is similar to that of the angle-compound engine. All the parts are supplied with oil from two central storage tanks, between the two vertical low-pressure cylinders, Fig. 1. The oil collects by gravity, is filtered and then returned to the elevated tanks by two pumps operated by the valve-gear rocker-arms of the horizontal cylinders. One of these pumps with its plunger can be seen to the left in Fig. 2.

There are indicator cocks for all four cylinders and a permanent reducing motion on each crosshead. The governor is the standard American-Ball inertia type, of use principally to prevent a runaway in case the load is seriously reduced by the clogging of the pump inlet.

Highest Powered Water Turbine—The highest powered water turbines ever built are the 22,500-hp. units recently constructed for the Washington Water Power Co. They will have an overload of nearly 25,000 hp. each. The builders, the I. P. Morris Co., are also constructing several 20,000-hp. vertical single-runner turbines for the Laurentide Co., Ltd., and nine, 10,800-hp. turbines for the Cedar Rapids Manufacturing & Power Co.

Editorials

What Can the Engineer Get?

A suggestion characteristic of the engineers' unwritten code of ethics is embodied in a letter on page 528 of the April 14 issue. In his reference to the results accomplished by "Engineer Wise," W. H. Odell says under the caption, "What Did the Engineer Get?" in the beginning of the second paragraph. "It may seem sordid," etc. This is professional pride. It is the trait of character or call it professional ethics, which is so frequently met with among engineers as to properly be called a fixed quantity or a constant. It entitles them to a high place in the scale of professions. They seldom discuss possible economies in the plant with any thought of profit to themselves. Who can remember such a suggestion on the floor of a lodge room (or anywhere else for that matter)?

Few of the professions equal, and certainly none excel in this characteristic. The lawyer is perhaps most frequently retained on a contingent basis, and the doctor the least. (A fee on the kill or cure basis might prove embarrassing to collect if the patient failed to recover). But the engineer performs all that he is nominally engaged to do, and besides, often effects economies as cited in the original article referred to, and expects no financial returns. All of which is splendid in itself, but does not furnish the present-day necessities nor do justice to his dependents.

There is enough brain in the craft and enough professional and financial standing if properly centered and utilized to enable the engineer of any plant to secure expert advice on his specific case to enable him to go to his employer with well developed plans of action or changes in order to produce results either in the line of extensions or economies with the straightforward business proposition that he is to benefit by it in a direct definite proportion to his employer. The plan is easy of execution through any of our engineers' organizations. Men of high standing are available to consult with and verify the possibilities of any given case and few are the plants which cannot show a handsome return on an investment which the engineer will be able to point out if properly received.

Employers will do well to give their engineers to understand that they will entertain suggestions along these lines. What a careful going over the old plants would have and best of all to the benefit and therefore the satisfaction of employer and employee. This is the life and solution of the isolated-plant problem; working along the lines of the central stations. State the case as the central station solicitor would state it. If within his heating zone, he would furnish heat and electric current each at a certain rate. If the isolated plant and engineer can do better, let them bid against the central station.

Rather than abandon his plant for "street current," almost any employer would prefer to make a contract with his own engineer to run the plant at less than central station rates, and to share the saving with the engineer. The bringing of this about is simply a question of the assertiveness of the engineer in urging his proposition, and the confidence of the employer in his ability to carry it out.

"Safety First"

During the past year many industries and corporations have concentrated the efforts of their ablest men on the "safety-first" movement—devoting time, thought and money toward means which would tend to eliminate by education conditions which are productive of accidents.

It has been well said that "accident prevention saves misery and money."

Until quite recently, this twofold saving has not been duly appreciated and in striving to increase output and sales the avoidance of accidents has been overlooked as one of the factors reducing the cost of operation. Employers have been somewhat slow in awaking to the fact that most accidents can be avoided, and do not seem to have seriously considered the great double saving to be effected through prevention.

An accident removes from his place for the time being the man his employer considers most capable in the line of work in which he is engaged. Through an injury the employer loses his man's services and must replace him, temporarily at least, with a less able man. Such an interruption cannot fail to show its effect on the efficiency of the factory or plant. It disturbs the productive power and brings suffering into the family of the injured.

A catastrophe avoided means lives saved and receivership averted. We can never reach a point where occupational accidents, or those accidents to labor, can be entirely eliminated, but it is the opinion of those well informed that the absence of systematic prevention work will cause the employer to contend with 30 to 40 per cent. more accidents.

Most of the conditions regarded as likely to cause accidents are not due to mechanical or electrical defects, but as a rule to simple hazards, easily removed. A workman's sense of prevention seems to be more one of avoiding an accident himself than of removing the cause of the accident, not only to himself, but to other employees as well. Telling workmen to be careful or oft-repeated warnings do not seem to have proved effective, but in using the experience of others and in applying the lesson directly, the workmen become aroused to the fact that they are the greatest losers through preventable accidents.

The greatest factor operating toward the prevention of accidents is not the prevention device but the prevention "spirit."

The Pennsylvania Railroad Company has reduced its accidents ninety per cent. in the past year as a result of the "safety-first" movement among its employees.

Report on Municipal Ice Plants

Many will remember that in the summer of 1913, Borough President George McAneny, of Manhattan, New York City, seriously considered the manufacture and distribution of ice to ameliorate the suffering among the poor during the hot months. That the problem might be thoroughly considered, a report on municipal and government ice plants in the United States and other countries, prepared by Jeanie Wells Wentworth, has been submitted to Borough President Marks, Mr. McAneny's successor.

The report reveals the fact that but one municipally owned and operated ice plant, in Weatherford, Okla., was discovered. The plant is operated in connection with the water and light plant, using the exhaust steam from the pumps and engines. The manufacturing cost is fifty cents per ton, forty cents of this being for labor and ten cents for fuel.

The report shows that for the years 1907, 1908 and 1909 the average cost per ton of ice for the Government Post Office Department, the Washington City Post Office and the Government Auditor's Office was $5.11. This is based on the consumption of 470 tons per season, which is from June to September inclusive. Careful estimates showed that the same quantity could be manufactured and delivered for $1033.06, or $2.198 per ton, resulting in a saving of $1368.64.

It appears that the high and increasing price of purchased ice forced the government departments to install ice-making machinery in department plants. The following quotations from a requisition by the Secretary of the Treasury for $3500 to install an ice machine in the Treasury Building is interesting: "The Treasury Department and outlying offices now (1909) use about 1,200,000 pounds of ice annually, and at the price quoted for the coming fiscal year (34 cents per 100 pounds in small quantities) the appropriation would not be sufficient to meet requirements." The total consumption at 34 cents per 100 pounds equals $4080.

After three years of governmentally operated ice plants, the report enables one to calculate that for 1913 the cost of manufactured ice for the Treasury Department is $2.00 per ton; for the Post Office Department, $2.42; for the Treasury Department, $3.90; for the State, War and Navy departments, $3.60. The savings per ton for these departments are $4, $2.18, $1.70 and $2 respectively. The total saving for the four departments for 1913 is $9672.90. All plants use live steam in the ice machines.

The subsistence department of the Isthmian Canal Commission produces about 110 tons of ice daily in the plant which it operates in the Canal Zone. With fuel costing from $4.15 to $4.20 per ton, and with high labor costs, the plant produces ice for $1.63 per ton; this includes part of the overhead charges.

After passing through the machines the steam, or rather condensate, is filtered and used for ice making.

The reports from plants abroad are not interesting as there seems to be a general lack of itemization of charge. This is especially true of England. The practice abroad is to charge about market price and turn the profits into the city treasury.

The Borough of Manhattan is now investigating the cost of harvesting ice outside the city and shipping it in as compared to manufacturing it.

Engineers of office and public buildings would do well to enter in their notebooks the ice data covering the government buildings. The figures will go a long way toward convincing the owners of institutions requiring ice or refrigeration of the advisability of installing their own ice plants.

When Ignorance Is Folly

Is ignorance a disgrace? That is a question which can be answered both ways; sometimes it is and again it is not, depending on circumstances. Whatever knowledge a man has never had occasion or opportunity to gain, he cannot be blamed for lacking. There is altogether too much to be known for anyone to "know it all." While there is a difference in capacities, no human brain can hold more than a wee bit of all there is to know. Consequently, it is almost as important to avoid loading up with useless knowledge as to seek that which is useful. The wise one is he who selects carefully. Ignorance of things there is no reason to know is, therefore, no disgrace.

Then when is ignorance a disgrace? Briefly, it is when its existence is realized and no effort is made to overcome it. There is a moral of an old fable which runs: "If a man fools me once, shame on him; if a man fools be twice, shame on me." By the same token, the first time a man discovers his ignorance of something he should know, it is no reflection upon him, but if he again finds himself wanting that knowledge, and in the interval has had the chance to get it, he deserves to be ashamed.

This leads up to the main thought, which is this: Don't be afraid to ask questions. Don't sit and look wise, and let the opportunity go by to learn something you need to know, because you are "ashamed to show your ignorance." The probability is that you make more of your want of information than anyone else. No decent fellow ever thought any less of another who confessed ignorance. On the contrary, it is quite in the nature of things to admire the chap who has the backbone to come out and say. "I don't know; tell me." Even if it is mortifying to expose one's ignorance, it is far better to do it once and have it over with than to go on not knowing and be again embarrassed, perhaps at a more critical time.

Times are fortunately changing in regard to the disposition to hide ignorance. In the early days of engineers' associations it was common to hold back the questions that many wanted to ask. As a consequence, discussions lagged, and little of interest, beyond what the lecturers offered, was brought out. Today, the discussion following a paper is likely to develop more of real value than the paper itself, because more and more, since the ice was broken, are those of the audience taking part.

If any encouragement is needed by those who are still backward, let them weigh the truth of this paraphrase of a familiar adage:

There is so much knowledge in the worst of us and so much ignorance in the best of us, that it hardly behooves any of us to criticise the rest of us.

The salesman on the right in the cartoon this week is getting two orders, anyway—"Get out!" and "Stay out!" and he deserves both of them.

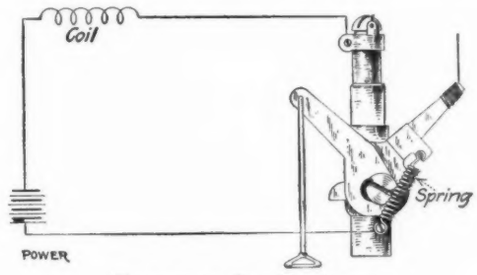
Correspondence

Self-Induction

Referring to Mr. Meade's article in the Feb. 17 issue, on "Calculating Power in Alternating-Current Circuits," attention is called to the common type of gas lighter or cigar lighter as illustrating self-induction. The current is supplied from two or three dry cells with a coil in series, as represented in the sketch.

In any coil the current rises to full value rather slowly, due to self-induction. That is, as the circuit is closed, the current rushes into the coil; but the lines of force set up produce an electromotive force in opposition to the electromotive force of the battery. Hence the effective electromotive force is the difference between that of the battery and that produced by self-induction, and the flow of current is checked.

When the circuit is opened the lines of force surrounding the coil, decrease rapidly; hence the electromotive force of self-induction is in a direction opposite to that set up when the circuit was closed and the lines of force were increasing. That is, the electromotive force of self-induction is now in the same direction as the electromotive force of the battery and the result is a greatly increased spark.



ELECTRIC GAS LIGHTER

A similar example is found in the inductive spark when opening a generator-field circuit when the machine is running. A transformer with an open secondary also illustrates the effect of self-induction, for it is this that limits the current flowing through the primary.

J. S. DODDS.

Hammering Check Valves

I do not think enough particulars are stated by A. E. Walden, in the Feb. 10 issue, under the above title. Many things may cause this trouble; for instance, the location of the checks, some systems having them on the return pipes of every radiator. Assuming that the checks complained of are at the bottom of the return risers, it is possible that the return pipes have pockets, or that some risers are using more steam than others, causing different pressures.

In my opinion, a system discharging into a receiver will give just as good results without a check. I once had this same trouble, but after removing the checks I never had any more. Perhaps the receiver vent pipe is too small. One could give a number of reasons for hammering check valves, but so many things are possible to affect the operation of a heating plant that it is difficult to offer suggestions that may be of value without fullest information of the layout of the heating system.

H. A. WHITAKER.

West Somerville, Mass.

Engineers' License Law Needed

If there is any state in the Union that needs to have licensed engineers it is West Virginia. Four or five of our largest towns have what they call city license laws, which are administered by the police departments, but as long as this continues no good results are possible.

I have worked in the state about 15 years and have had some funny experiences with men. A short time after I took charge of one plant the night man quit without giving notice. The superintendent told me he would send a man up to run the plant that night. When the man came he told me that he had worked in the mines and at carpenter work. About 10 o'clock he blew the whistle, and I hurried over and found him in the boiler room on a ladder at the water column. He had blown down the boiler, and the water was out of sight in the glass. The result was I had to put 18 new tubes in the boiler, which was a 250-hp. Stirling.

The boiler inspector called around one evening and he told me the following day about his talk with the night man. He said, "Why that man is dangerous to have in a plant like this. When I asked him how much steam pressure he was carrying, he told me he was only carrying 125 lb., but could carry a lot more if he wanted to, as the steam gage would carry 250 lb." When I quit, about eight months after he went to work as night man, the superintendent put him in charge as engineer.

At a coal-mining plant one morning when the day man relieved the night man he found that the water was out of sight, and the crown-sheet burnt; all the tubes had pulled loose and the soft plug was melted, but it was covered over with scale a quarter of an inch thick, which had to be broken with a punch.

Even after this the superintendent put a young man on the night shift, who had never been around boilers, and knew nothing about them.

Not long ago I was down at a sawmill, where they were using an old fire-box boiler, from which the gage-cocks had been removed, and the holes plugged, and I would hate to vouch for the steam gage. I asked the fireman how he could tell the height of water in the boiler, and he replied that he did not know for sure, but kept the pump running all the time, and if the water got too high and went over in the engine he could let some of it out. He did not say what he would do if the water got low. In fact, there was no way of telling the water level.

Now I do not mean to say that there are no first-class

engineers in the state, because there are, but they have to compete with and work for a third- or fourth-class man's salary, which is about $50 to $65 per month. I know of one engineer who runs a plant, which has three boilers of 1000 hp., two alternating-current generators, one large direct-current outfit for street-car service, one motor-generator set, and three pumps, and does his own firing for $60 a month. He works 12 hr. per day for $720 a year, not quite 17c. an hour. The pay for common labor is $1.75 to $2.25 a day of 10 hr. What encouragement has a man to study and work a lifetime, trying to qualify himself to be a first-class engineer, when they pay as much or more for common labor? The company that hires incompetent engineers pays out more money, including repairs, in a year than if only first-class men were engaged at good wages.

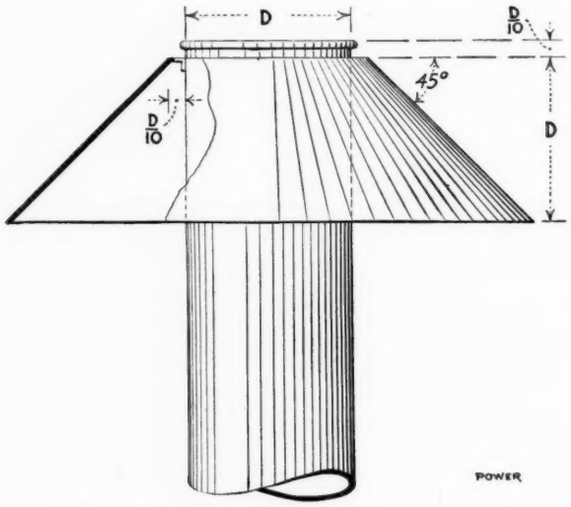
WALTER B. BEHEN.

Belington, W. Va.

Device Improves Stack Draft

The arrangement described herewith is one which makes use of the potential energy in the winds blowing about a stack to improve the draft, and is especially suitable where the winds ordinarily tend to impair the draft of a stack, as where a large expanse of flat roof surrounds it. Even in the case of a down draft on the stack, the arrangement will help eliminate the bad effects.

The arrangement consists of a collar of iron of frustrum form, attached to the stack close to its upper end. The collar should be spaced a slight distance away from the stack by suitable straps, so that up-coming currents of air can readily pass between the frustrum and the stack. The general proportions of the collar, expressed



HOOD ON STACK TO IMPROVE DRAFT

in terms of the stack diameter, are indicated on the sketch.

The action of the arrangement is as follows: Horizontal winds are guided upward and create a vacuum about the end of the stack and improve its draft. Winds or currents going up under the collar will be compressed as they approach the top of the stack, owing to the wedge shape of the collar, and will exit through the top and by the open end of the stack with speed, assisting at the same time the currents flowing up on the outside of the collar. The collar will also act as insulator for the end of the stack and thus keep the gases at the point at a higher temperature. A downward flow of air currents on the stack will be broken and guided out from the stack, so their effect will be diminished.

Boiler-Blowoff Accident

This letter is intended to bring before operating engineers and boiler inspectors a most unusual condition found by the writer recently in one of Philadelphia's leading hotels. It was a daily practice at this plant to blow down about 2 in.

The blowoff arrangement was of the usual design, a

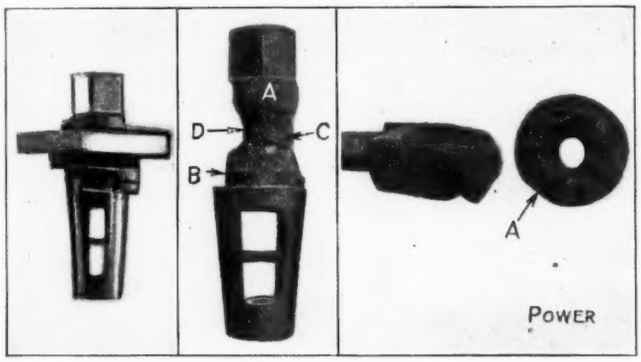


FIG. 1. FIG. 2. FIG. 3.

plug cock nearest the boiler and a valve about 2 ft. away. The engineer had opened the valve and started to open the cock. When about half-way open the stem broke off, the top part of the stem and the handle coming away in his hand.

Under ordinary conditions this would not have been serious, because the valve could have been shut and the water retained in the boiler, but in this instance the conditions were so unusual that in 20 min. the two boilers were emptied, the water escaping through the fractured end of the plug. Prompt action saved the boilers from injury. When the water was all away an examination of the plug cock showed an inch hole in the stem, leading directly from the port in the plug to the point of fracture. Later, when the broken plug was taken from the body of the cock, another serious condition was observed, and perhaps more likely to be found than that shown in Fig. 1. There had been a most extensive corrosion taking place under the gland.

From Fig. 1 one would imagine that it was a new cock, for the metal above and below the gland is in perfect condition, as clean as on a new plug and the edges all perfect, but when the gland is removed, see what has taken place between the top of the gland and the top of the packing, Fig. 2.

It is assumed that some strong corrosive had entered from an outside source and laid on the packing, which was in perfect condition.

Fig. 3 shows the inch hole in the center stem *A*. It is as clean as though drilled, and perfectly round. The break shows clean, too, there being no sign of a crack or a leak through the pores of the iron. No serious damage was done, although the engineer was slightly scalded on the face. All blowoff cocks found with a hollow stem should be condemned and removed. One with a worn

and gear opening attachment is preferable, it can be opened easily and gradually and there is no danger of opening suddenly, as may be done by a lever.

R. W. Robinson.

Germantown, Penn.

Care of Boiler during Shutdown

A striking example of the bad effects resulting from the frequent practice of allowing a boiler to stand full of water during a shutdown has recently come to the attention of the writer. Two 260-hp. water-tube boilers were shutdown in April, filled with water at that time and allowed to stand idle until December. Upon inspecting these boilers, preparatory to starting up, a coating of about $\frac{1}{32}$ in. of rust was found covering the outside of the tubes. To remove this scale by scraping would have been an almost endless job, so a flat nozzle was made at the end of a ¼-in. pipe and compressed air used. This stream of air removed the coating of rust nicely but the plant was subject to delay in starting up besides the damage to the tubes.

The rust is caused by "sweating," or the condensation of moisture from the atmosphere upon the tubes, and occurs whenever the temperature of the tube or the water in the tube is lower than that of the surrounding air. The proper way to prepare a boiler for a shutdown is to clean it thoroughly, both inside and out, drain it of water and remove the manhole covers, allowing free circulation of air to all parts of the boiler. This applies to fire-tube as well as water-tube boilers.

F. E. Worley.

Providence, R. I.

Where Should the Oil Separator Be Located?

In answer to the article under the above heading, in your issue of Mar. 31, by G. S. Sprague, I beg to submit the following which may help him and other Power readers:

An oil separator of the type shown should have an efficiency of from 95 to 99 per cent. elimination of the total quantity of oil used. There seems to be no reason why much better results are not obtained with it in its present position, provided, of course, it is large enough for the service.

I do not agree with the "rival salesman" that "no separator so located would work satisfactorily," or that the separator should get the steam as free from water as possible. It is a well known fact that oil can be removed more effectually from wet than from dry steam. Perhaps Mr. Sprague is using an oil which is too volatile, thus allowing some to go through the separator without striking the baffles at all. A common trouble is imperfect drainage, but this one, we are told, is well drained. The baffles should be frequently cleaned.

J. E. Poche.

New Orleans, La.

The writer designed a plant in which the location of the separator in reference to the engine is almost identical to that shown in Mr. Sprague's sketch. This plant has been in operation for over a year and the boilers show no sign of oil having passed the separator during that time.

As a matter of fact, the location of an oil separator is not of great importance, while the design of it is everything. One of the most efficient types is one in which the velocity of the steam is reduced to a few hundred feet per second and provided with suitable fluted baffles to catch the oil. For a 7-in. pipe it should be about 24 in. in diameter and 5 ft. long.

The type Mr. Sprague has, as indicated by his sketch, is so small that the velocity of the steam is too high and the travel too short to remove all of the oil.

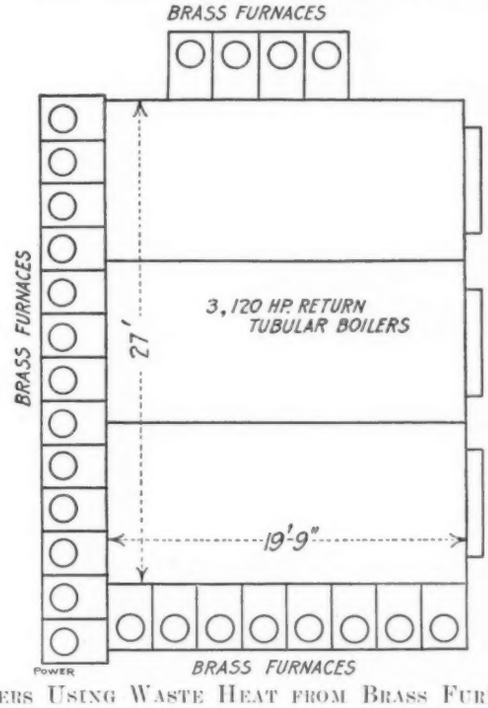
I should advise Mr. Sprague to replace his present separator with one of known efficiency. If this is done no further trouble with oil should be experienced.

W. L. Durand.

Brooklyn, N. Y.

Brass Furnaces around Boiler Setting

At a plant in Iowa is a novel arrangement of brass furnaces in connection with boilers. As seen from the diagram, these furnaces are grouped directly around the boiler settings, there being eight on one side, four on the other, and 13 at the back. These furnaces discharge directly through short flues into the setting, all openings



Boilers Using Waste Heat from Brass Furnaces

being back of the bridge-wall; thus the hot gases sweep through the boiler tubes and to the stack. An average of 14 of the brass furnaces are in continuous operation, anthracite coal being fired.

Many engineers have expressed their opinions on the relative evil or beneficial results from these furnaces as arranged, their claims ranging from 10 to 15 per cent. loss to 30 or 40 per cent. gain. Until recently there was no definite information as to what the results really were, until the writer made a few simple tests, using bituminous coal on the boiler grates and anthracite in the brass furnaces.

The steam-generating plant consists of three 120-hp. return-tubular boilers, arranged side by side, as shown, the grate area of each boiler being 27½ sq.ft. Several 24-hr. tests were run on different days, the coal fired being carefully weighed and the feed water measured by a hot-water meter. The results showed an average coal consumption on the three grates of 778 lb. per hr., and an evaporation of 7357 lb. of water per hr., making an evaporation rate of 9.45 lb. of water per lb. of coal. At this rate 9.4 lb. of coal were being consumed per square foot of grate surface per hour, the coal being a good grade of bituminous.

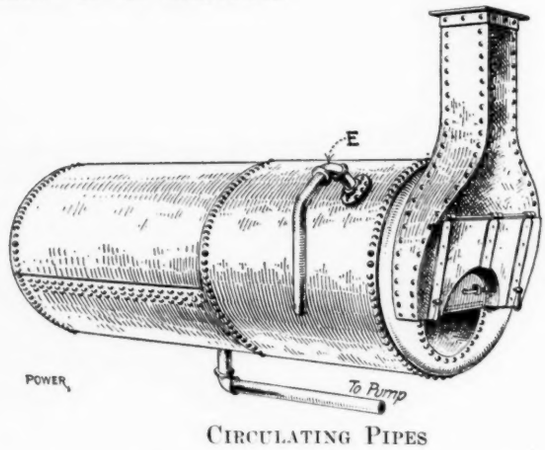
That the furnace conditions were far from ideal was evidenced by the average flue-gas analysis, which showed 5.5 per cent. of CO_2. It would, therefore, seem that the excellent evaporative rate was due to the use of heat from the brass furnaces. The average steam pressure is 100 lb. per sq.in. With a feed-water temperature of 202 deg., the evaporation rate gives an equivalent evaporation from and at 212 deg. of 9.92 lb. of water per lb. of coal. It is anticipated that these results can be improved by stopping numerous leaks in the boiler setting, and completing an induced-draft system now being installed. The present stack is inadequate for the load, as it is but 28 in. square on the inside and about 80 ft. high. The induced-draft system will have a 90-in. exhaust fan, directly connected to a vertical engine, the fan and engine being mounted on the boiler-house roof in a small house. Dampers are so arranged in the breeching that the furnaces may be either switched from the stack, or the fan, or two furnaces may be run on induced draft and one on natural draft.

GRANDON D. GATES.

Dubuque, Iowa.

Forced Circulation

To avoid leaks from unequal expansion in Scotch boilers, marine engineers often connect to the suction of the feed pump a bypass from the bottom of the boiler, as shown in the illustration.



CIRCULATING PIPES

Some water is thus drawn from the bottom of the shell and returned at the regular feed point *E*, which tends to equalize the temperature throughout. This is especially desirable when getting up steam.

C. R. MCGAHEY.

Baltimore, Md.

The Language of Ordinances

Your editorial, under the above title, in the Mar. 17 issue, is interesting and pertinent. As the language of the ordinance, although probably the work of one man, was acted upon by the council, every councilman stands arraigned, since any one of them could have challenged it. Probably, also, it was furthered and viséed by several men connected with steam-plant practice in Reading. Be this as it may, the main responsibility is certainly upon the councilmen.

It is a matter of regret that the standard of engineering English is as low as it is, although certainly it is improving, and at a rapid rate. Certainly, also, the engineering magazines have done and are doing much toward this end. Although it is sometimes true, it is always difficult to believe that clear thinking can be an accompaniment of slovenly writing.

H. L. H. SMITH.

Brooklyn, N. Y.

Core Water Cools Ammonia

The place utilizing the following plan of cooling liquid ammonia was a raw-water ice plant having the usual apparatus for pumping the core water out of the ice cakes just before they are formed, and filling the centers with distilled water to produce clear ice.

The core water pumped out leaves the cans at 32 deg. F., and runs through an open-box flume to a near-by stream. The ammonia condenser and liquid receiver are quite some distance from the freezing tank and near the flume carrying the core water from the tank. The liquid line between the ammonia receiver and expansion header on the freezing tank was run about four-fifths of this distance submerged in the cold core water, which delivered the liquid ammonia to the expansion valves at a much lower temperature than that at which the ammonia was condensed in the condensers.

Of course, this cold water for cooling the liquid ammonia is available only at such times as the ice cakes are being pumped out, but this extends over quite a period when the plant is in full operation. The installation of this liquid cooler has paid for itself many times.

C. T. BAKER.

Jacksonville, Fla.

Boilers to Cool Jacket Water

It might interest some readers to learn that it is quite satisfactory to use steam boilers for cooling gas-engine jacket water.

The company with which I am connected has a combination gas engine and steam plant, and two idle boilers, one a 100-hp. fire-tube, and the other a 150-hp. water-tube are used to cool the jacket water. The water is circulated by a 1-in. direct-connected, centrifugal pump, into a sight-feed funnel and then distributed to the boilers in proportion to their cooling capacity. The dampers, of course, are kept wide open.

The outlet is at the blowoff and the water is put into the boiler as far as possible from where it is taken out. The gas engines are 125- and 80-hp., Westinghouse three-cylinder vertical units.

N. E. WOOLMAN.

Kittanning, Penn.

Inquiries of General Interest

To Detect Cutting of Brasses—How can cutting of crank-pin brasses be detected without removing them for examination?

S. J. G.

After the engine has been running awhile take some of the oil that has worked out of the brasses and spread it on a piece of white paper; if the brasses are cutting, fine particles of the metal will be found.

Pressure in Pump Air Chamber—Neglecting pressure due to friction in the discharge pipe, what is the pressure per square inch in an air chamber on the discharge side of a pump in pumping water against a head of 67.6 ft.?

W. D.

The pressure for each foot of head of water is equivalent to 0.433 lb. per sq.in. and the air-chamber pressure would be

$$67.6 \times 0.433 = 29.27 \text{ lb. per sq.in.}$$

Pump Water Cylinder Length—Why is the water cylinder of a pump made longer than the steam cylinder?

J. R.

So there may be plenty of clearance space for easy flow of the water into or out of the cylinder when the piston is near the end of its stroke and to afford latitude for adjustment of the stroke of the piston rod with reference to the stroke of the steam piston and proper equalization of steam-cylinder clearance.

Higher Boiler Efficiencies with Oil Fuel—Why are higher boiler efficiencies obtainable with oil fuel than with coal?

A. J. S.

With oil fuel the furnace doors need not be opened while the boiler is under steam, and with proper regulation of burners the oil can be burned with admission of little more than the amount of air necessary to furnish the oxygen necessary for the combustion; and the heating surfaces are not so quickly fouled by soot.

Determining Condition of Check Valve—In a low-pressure steam-heating plant how can it be determined whether the noise made by a check valve on a radiator or a dry return connection is due to ordinary operation of the check or to its derangement?

J. M.

If the valve is in proper working order it will remain closed and will prevent back flow when the supply is cut off from the radiator or other part of the system discharging through the check valve. If the check is not working properly, back flow would cause the radiator or return to become filled with water.

Direct vs. Indirect Spring-Loaded Safety Valves—What is the difference between a direct spring-loaded and an indirect spring-loaded safety valve?

J. C. A.

A direct spring-loaded safety valve is one in which the valve is held down by the direct action of a spring, while an indirect spring-loaded safety valve is one in which the spring holds the valve down through levers or other mechanism between the spring and the valve. An ordinary ball-and-lever safety valve having the lever held down by the tension or compression of a spring would be an example of an indirect spring-loaded safety valve.

Stopping Position of Crank—In shutting down an engine why does the crank stop a little past dead center oftener than at any other point of the stroke?

J. W. D.

When an engine is stopping, most of the momentum being in the flywheel the latter is driving the connecting rod, crosshead and piston. The velocities of the reciprocating parts, relative to the flywheel speed, rapidly decrease as the dead center is approached, consequently the load on the flywheel is then diminishing so there is less tendency to stop. Immediately the center is passed, however, these conditions are reversed and the stopping effect of the reciprocating parts becomes greater and greater until midstroke. Therefore, if the engine gets by midstroke it is likely to keep moving until the next dead center is passed.

Boiler Horsepower Developed—A boiler consumes 280 lb. of coal per hour, the coal having 14,000 B.t.u. per pound. Assuming that 70 per cent. of the heat of the coal is utilized in making steam, what boiler horsepower is developed?

C. C. W.

The heat realized would be:

$$70\% \text{ of } (280 \times 14{,}000) = 2{,}744{,}000 \text{ B.t.u. per hr.}$$

A boiler horsepower is equivalent to the evaporation of 34½ lb. of water per hour from and at 212 deg. F., and the net amount of heat required for one boiler horsepower is

$$34\tfrac{1}{2} \times 970.4 \text{ B.t.u.} = 33{,}479 \text{ B.t.u. per hr.,}$$

therefore the boiler horsepower developed under the conditions stated would be:

$$\frac{2{,}744{,}000 \text{ B.t.u.}}{33{,}479 \text{ B.t.u.}} = 81.96 \text{ b.hp.}$$

Cracked Tube Sheet—Is there any way to fix up a crack in the tube sheet of a horizontal return-tubular boiler? The crack is between two tubes in the rear head and has been kept tight for a month by calking.

J. A.

A crack in a flue sheet indicates a weakness which might result in a serious explosion and the flue sheet should be renewed or the use of the boiler abandoned. We cannot commend any other repair as safe even though the boiler does not leak. It is possible, however, that the crack is such that it could not lead to serious damage, and if the owner and operator of the boiler are satisfied to take the risk, such a leak could be stopped, although not made any safer, by drilling and tapping a number of holes, about ⅛ inch diameter, the full length of the leak and close together, screwing in screws made of copper wire and then peening over their ends with a light hammer to make a tight calked joint. Such a repair may do for an emergency, but should not be depended upon longer than necessary.

Saving of Feed-Water Heater—In a plant where steam is generated at 90-lb. gage pressure and the temperature of the boiler feed water is 60 deg. F., and the exhaust at present wasted what would be the per cent. of saving if the temperature of the feed water is raised to 210 deg. F. by an exhaust steam feed-water heater?

H. C.

With feed water at 60 deg. F. each pound contains 60 — 32 = 28 B.t.u. above 32 deg. F., and as 1 lb. of steam at 90-lb. gage pressure contains 1187.3 B.t.u. above 32 deg. F., then to raise a pound of feed water at 60 deg. F. into a pound of steam at 90 lb. gage pressure requires the addition of

$$1187.3 - 28 = 1159.3 \text{ B.t.u.}$$

With feed water at 210 deg. F. each pound would require 210 — 60 or 150 B.t.u. less than with feed water at 60 deg. F. Therefore, if no additional back pressure is brought on the engine by using an exhaust-steam feed-water heater the saving would be

$$\frac{150 \times 100}{1159.3} = 12.94 \text{ per cent.}$$

Water Siphon—Is there any limit to the height over which water can be siphoned out of a reservoir?

C. G. L.

It is the pressure of the atmosphere which operates a siphon and it would be impossible to siphon water over a height greater than the height of a water column which would be sustained by the pressure of the atmosphere. At sea level and with a temperature of 62 deg. F. the pressure of the atmosphere is 14.7 lb. per sq.in., which is the same as the pressure per square inch at the foot of a column of water 33.94735 ft. high. With less atmospheric pressure, as in elevated localities where the barometric pressure is less a correspondingly less height of water column would be sustained and the water can be siphoned over a correspondingly less height. The siphon would not continue to operate if the height of the intake leg were greater than about 33 ft., because a vacuum space would be formed at the crest of the siphon, the flow would break at that point, and the action of the siphon would fail because the atmospheric pressure would be insufficient to elevate the water to the top of the inlet leg.

Engineers' Study Course

Elementary Mechanics--V

Last Lesson's Answers

16. In Fig. 18, let OA equal the force of 100 lb. and OB the force of 80 lb. Construct the parallelogram $OACBO$ and draw the diagonal OC to give the resultant force R.

From equation 5, Lesson II,

$R^2 = 100^2 + 80^2 + 2 \times 100 \times 80 \times \cos 60$ deg.;
$= 10{,}000 + 6400 + 8000 = 24{,}400$;
$R = 156.2$ lb.

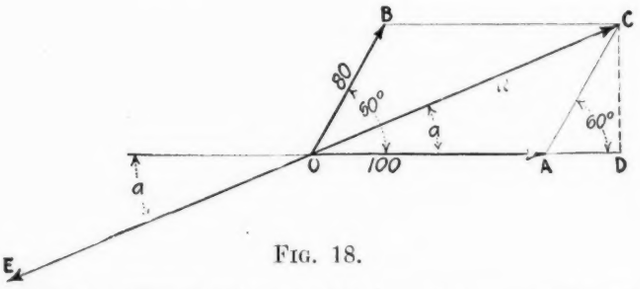


Fig. 18.

Draw CD perpendicular to OD then $CD = AC \sin 60$ deg. $= 69.3$ and $AD = AC \cos 60$ deg. $= 40$

$$\tan a = \frac{CD}{OD} = \frac{69.3}{140} = 0.495$$

therefore, $a = 26$ deg. 20 min. The equilibriant of a system of forces is equal and opposite to the resultant of these forces. Therefore, the line OE, which is equal and opposite to OC, is the desired force and makes an angle of 26 deg. 20 min. with the horizontal.

17. Refer to Fig. 17 of last week's lesson. In this case the angle $NOH = 35$ deg. The line $ON = T = 2000$ lb. and the line NH represents the unknown load W.

$$\frac{NH}{NO} = \sin 35 \text{ deg.} = 0.574$$

hence

$NH = NO \sin 35$ deg. $= 2000 \times 0.574 = 1148$ lb.

18. The tension in the link OB is the resultant of the weight W of the ball, and the centrifugal force C. In the triangle $BONB$ (see Fig. 15 of last week's lesson), the force OB is equal and opposite to the resultant of the weight W and the centrifugal force OF.

Also

$NB = OE = W = 40$ and $ON = OF = 30$

therefore

$OB^2 = T^2 = ON^2 + NB^2 = 30^2 + 40^2 = 2500$

or

$T = 50$ lb.

19. The tension in the tie-rod AC will be decreased since part of the weight W is now taken by the point B, where previously it was all taken by the point A.

20. The pressure at B will no longer be horizontal since part of the weight W is acting at the point B. The pressure on the point B is equal to the resultant of the pressure in the strut AB and the part of the weight taken by the point B. Draw a vertical line through the center of the line AB until it intersects the line AC. A line connecting this point with B will give the direction of the pressure on the point B. Proof: If three forces acting on a body produce equilibrium, the lines of action of these forces pass through a common point. (See Lesson IV.)

Law of Sines

From the lessons in trigonometry the student doubtless recalls the rule that in *any triangle any side is proportional to the sine of the angle opposite the given side.* (*Law of sines.*) This law can be used to solve the force triangle when it contains no right angle. For example, take the case of a weight W suspended from two tie-rods which are pivoted at the points A and B and make angles with the horizontal, as shown in Fig. 19. What will be the tensions in the rods OA and OB? Draw the triangle $OACO$ having the side AC parallel to OB and the side OC proportional and parallel to the weight W. In this triangle the side OA is proportional to the tension T_2 and the direction of the force is from O to A; AC is proportional to T_1 and its direction is from A to C; the side CO is proportional to the weight W and its direction is from C to O. Hence the three forces acting on the point O are represented by the sides of the triangle $OACO$ taken in order. By construction the angle CAB equals 30 deg. since AC is parallel to OB. Therefore, the angle $ACO = 60$ deg. (Note—The sum of all the angles

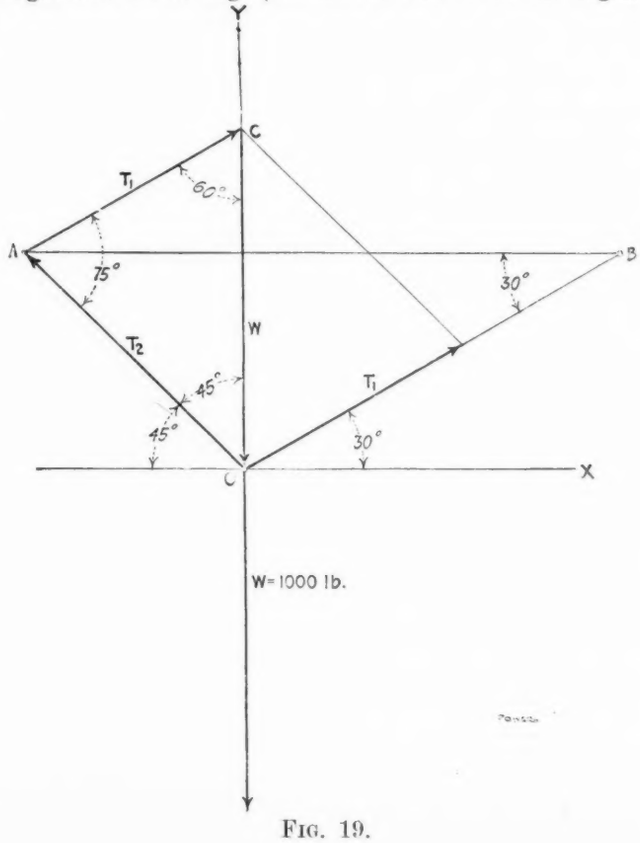


Fig. 19.

of any triangle = 180 deg.) For the same reason the angle COA = 90 deg. — 45 deg. = 45 deg. The angle opposite the side CO, or W, is 75 deg.; opposite the side AO, or T_2, the angle is 60 deg.; and opposite AC, or T_1, the angle is 45 deg. Now apply the law of sines and there result these equations

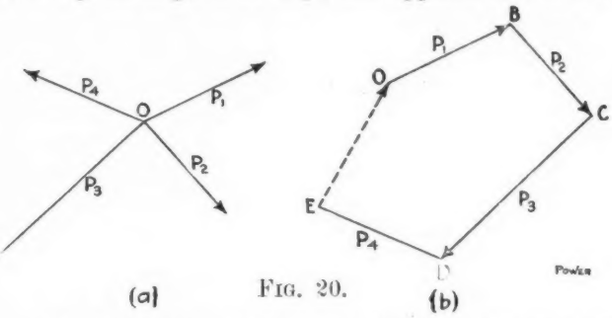


FIG. 20.

$$\frac{T_1}{\sin 45 \text{ deg.}} = \frac{W}{\sin 75 \text{ deg.}}$$

also

$$\frac{T_2}{\sin 60 \text{ deg.}} = \frac{W}{\sin 75 \text{ deg.}}$$

hence $$T_1 = \frac{W \sin 45 \text{ deg.}}{\sin 75 \text{ deg.}} = \frac{1000 \times 0.707}{0.966} = 732 \text{ lb.}$$

and $$T_2 = \frac{W \sin 60 \text{ deg.}}{\sin 75 \text{ deg.}} = \frac{1000 \times 0.866}{0.966} = 897 \text{ lb.}$$

For those who are familiar with the law of sines the above solution will be easy. For the benefit of those not familiar with the law the problem will now be solved by resolving the forces into their horizontal and vertical components and applying the laws $\Sigma H = O$ and $\Sigma V = O$. Use the point O (Fig. 19) as the origin and draw the two axes OX and OY through this point. The horizontal component of the tension $T_1 = T_1 \cos 30$ deg. and the vertical component $= T_1 \sin 30$ deg. Likewise the horizontal component of $T_2 = -T_2 \cos 45$ deg. (this is minus because the component is acting to the left). The vertical component $= T_2 \sin 45$ deg. The horizontal component of $W = W \cos 90$ deg. $= 0$ and the vertical component $= -W$ (minus because W is acting downward).

Therefore,

$$\Sigma H = T_1 \cos 30 \text{ deg.} - T_2 \cos 45 \text{ deg.} + 0 = 0$$

then $$0.866\ T_1 - 0.707\ T_2 = 0$$

hence $$T_1 = \frac{0.707\ T_2}{0.866} = 0.8164\ T_2$$

also $\Sigma V = T_1 \sin 30 \text{ deg.} + T_2 \cos 45 \text{ deg.} - W = 0$

then $$0.5\ T_1 + 0.707\ T_2 - 1000 = 0$$

or $$0.5\ T_1 + 0.707\ T_2 = 1000$$

Substitute in this equation the value of $T_1 = 0.8164\ T_2$ and there results

$$0.5 \times 0.8164\ T_2 + 0.707\ T_2 = 1000$$

or $$1.1152\ T_2 = 1000$$

$$T_2 = 897 \text{ lb.}$$

and $T_1 = 0.8164\ T_2 = 0.8164 \times 897 = 732$ lb.

By a comparison of the two solutions it is seen that the method of sines is much shorter than the method of components and for this reason the student is urged to study the law of sines and to combine it with the triangle of forces in the solution of subsequent examples.

Polygon of Forces

Thus far only two- and three-force problems have been considered, but frequently problems will arise in which there are four or more forces acting at a given point. In such cases the principle of the triangle of forces is extended to include the *polygon of forces*.

Rule: *If any number of forces in the same plane, acting at a given point on a body produce a state of equilibrium, these forces can be represented in magnitude and direction by the sides of a polygon taken in order. Conversely, if any number of forces in the same plane acting at a given point on a body can be represented by the sides of a polygon taken in order, the forces will be in equilibrium.*

The polygon of forces can be used to determine the force necessary to balance a system of forces. In Fig. 20a, the four forces P_1, P_2, P_3 and P_4 act at a given point O. Do these forces produce equilibrium? In Fig. 20b, draw OB parallel and equal to P_1, BC parallel and equal to P_2, CD parallel and equal to P_3 and DE parallel and equal to P_4. There is thus formed the figure $OBCDE$ which is not a closed polygon and hence the forces are not in equilibrium. A line drawn from the point E to the point O will represent the magnitude and the direction of the force required to balance the system. The student can prove the truth of this statement by applying the parallelogram law to determine the resultant of the forces P_1, P_2, P_3 and P_4 as explained in Lesson II. The force necessary to produce equilibrium will be equal and opposite to the resultant thus found, and must be equal to the line EO.

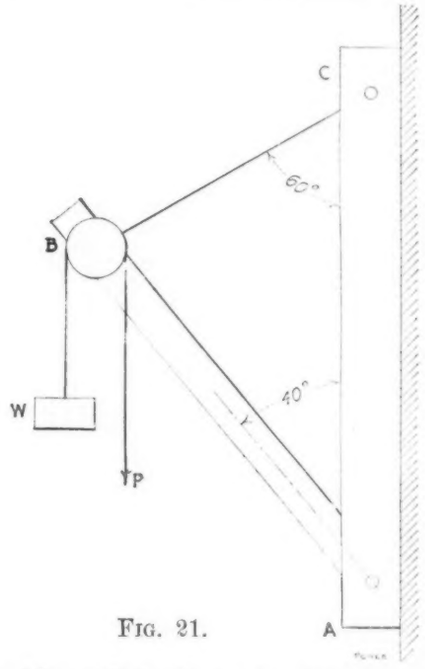


FIG. 21.

Study Questions

21. In Fig. 21 determine the tension in the tie-rod BC when the weight W = 600 lb. (Note: P = 600 lb.) Solve by the aid of a force triangle.

22. Find the compression in the strut AB.

23. What produce the reactions necessary for equilibrium in Fig. 21?

24. Using the magnitude and directions of the forces given in problem 10, Lesson II, and, replacing the resultant force of 144 lb. by an equal and opposite force, construct a force polygon.

25. Are the forces in problem 24 in equilibrium? Give a reason for your answer.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Over a million dollars worth of horses die each year in New York City, according to the New York Edison Co. If you'll be the goat, the answer is that this sum will buy a thousand electric trucks. Whoa, Dobbin, here comes a truck!

Some speed! A projectile from a 12-in. gun travels at the rate of 25,000 miles a minute, being released at a pressure of 40,000 pounds to the square inch. It hits the mark ahead of its own sound.

A New Haven medico asserts that the average office boy wastes as much energy in walking about the office in a day as it would take to shovel 15 tons of coal. If the efficiency experts hear this, they will advocate putting office boys in the boiler room.

"Get the Personal Touch!" says an automobile advertiser. It's bad advice. And to make it worse, he further states, "Get the feel of the car!" Loads of people have already got the feel of a car, and afterwards hobbled around on crutches—if they were able to save the pieces.

There is an enormous demand for nicotine for spraying grapevines in France, says a consular report. It's a pity Jacques cannot import some of those engine-room "sprayers" we used to know. They, too, had an "enormous demand for nicotine"—usually off the other fellow's plug.

Oh, you great big beautiful New York! Your legislators, after an all-day and an all-night session, made "Packy" McCabe a Conservation Commissioner. We'll get conservation now, and then some! If we don't get the doughnut, we'll get the hole—and there are only two parts to a doughnut, anyhow.

Some Chicago scientists are making arrangements to weigh the moon. They're always trying some stunt out that way to get ahead of the effete East. All winter we've been trying to figure out how 16 hundred-pound bags of coal make a ton.

Hooray for the grape-juice government! The Secretary of the Navy says no more beer or liquor for the navy. Even their ladies cannot have a "stick" in their pink tea. (One minute, please, while we change the reel.) Next go for tobacco-users. Once we knew a navy man who smoked and he died an orphan at 92, with no one to advise him. If he hadn't smoked he might have lived to be 70—and died when he was of more use.

A some keen Frenchman, one Talleyrand, once remarked that language was an instrument for concealing thought. This gem scintillates most brightly in a legislative bill for the water-power rights gobbler, or in an act aimed at a rival lighting company to hit its competitors. Reduced to a common figure, it's a "joker."

While the suffragetters can't go back to Hero, like us, there are records of them in Denmark, in 1722. Sille Gad is the name of one of the original settlers. Do you suppose that these two Danish words can be translated literally into English?

Sure hope you glimpsed a modest personal about William T. Travers in the Apr. 7 issue. Mr. Travers served 44 years as engineer of Brooklyn's Prospect Park pumping station. Know any engineer who can equal this record? If so, let's have his name that we may do him proud.

Waxing facetious over King George's recent fireplace invention, "Engineering News" says that in view of late developments in British politics, it may be a good thing to have a trade to fall back on. Don't you mind 'em, friend King. You stick to "Power;" there's lots of good openings for a fireplace man over here, so if the worst is yet to come, just drop us a line.

Wilson-Snyder Centrifugal Pump

This pump is designed along new lines with the purpose of minimizing leakage, to prevent the leakage current from disturbing the main flow of the fluid entering the impellers of the pump, and to properly direct the flow of the liquid into the impellers. Attention has also been given to the reduction of friction at the tightening joints by avoiding contact between the fixed and rotating parts.

Three points of main importance have been considered by the designer. The first one is that the direction and

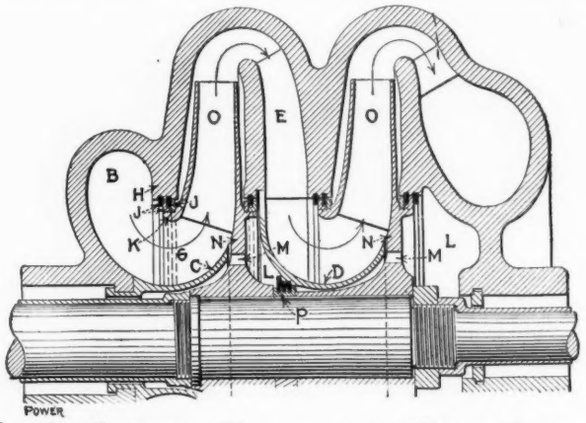


FIG. 1. SECTIONAL VIEW THROUGH WILSON-SNYDER CENTRIFUGAL PUMP

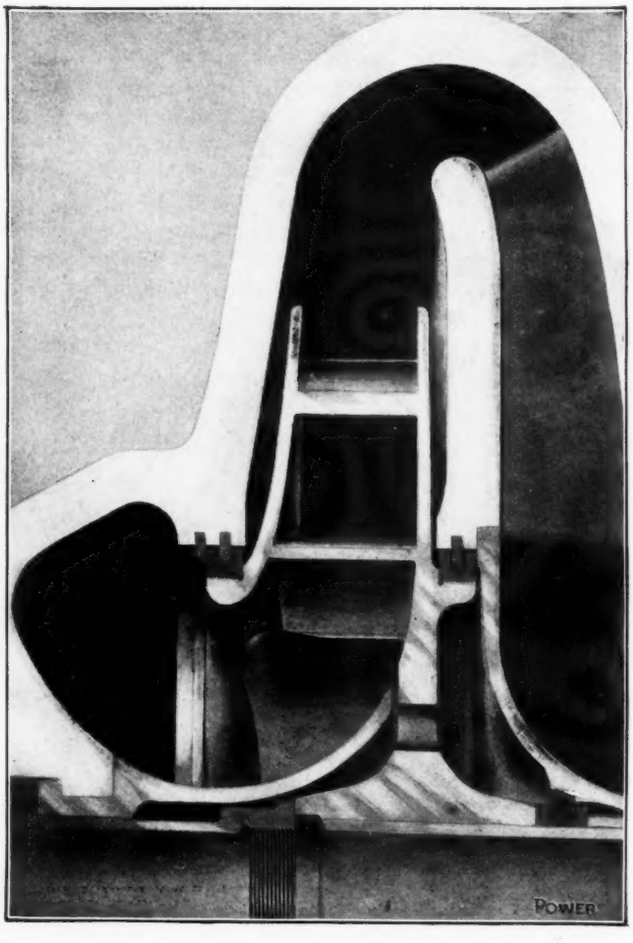


FIG. 2. ENLARGED SECTION OF IMPELLER AND TIGHTENING BOX

the velocity of the liquid at the point of contact with the first element *A*, Fig. 1, of the vanes, or vane inlet, are fundamental factors in the calculation and delineation of the shape of the vanes. If, then, anything occurs to deviate the direction and change the velocity of the liquid at the vane inlet, the performance of the pump will be different from what was intended. The second point is that as the liquid leaves the impeller, nothing can add to the energy it possesses, and every surface with which it comes in contact will cause a reduction of energy, the delivery must, therefore, be well proportioned and made

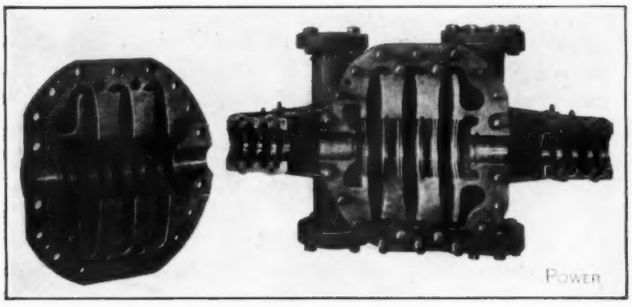


FIG. 3. INTERNAL VIEW OF PUMP CASING

very smooth. The third point concerns the conservation of the energy generated by the impeller, and, consequently, the prevention of the cause of loss of that energy through leakage at the running joints The design of this pump seems to cover these three points.

Referring to Fig. 1, the inlet water enters the pump casing through the passage *B*, and follows the removable conoidal guide shell *C*, which surrounds part of the hub of the first impeller, the shaft and its protecting sleeve *D*. The guide shell is so designed that when fitted in place it does not come in contact with the rotating members of the pump and forms an effective guide for the liquid from the intake chamber *B* to a point close to the vane inlet *A*. A conoidal guide shell *D* surrounds the hub of the second impeller and acts as a guide for the liquid from the passage *E* to the vane *F* of the second impeller. This arrangement of the guide shells causes the incoming liquid to flow smoothly into the impellers and prevents the said liquid from coming in contact with the surface of the rotating parts until it has rached the vane inlet. Thus the incoming water engages the impeller vanes while in an undisturbed state and in the direction originally adopted by the designer as one of the data upon which the calculation for the impeller are established.

Upon discharging from the impeller the water, then under pressure, tends to flow past the impeller into the inlet chamber *G*, but is prevented by a tightening running joint between the casing wall *H* and the inlet flange of the impeller. This joint is composed of the four annular flanges *J*. The lower flanges are separately mounted on the external wall of the impeller-inlet flange *K*. The two upper flanges are each inserted into the wall *H*, which surrounds the entire tightening device. A slight lateral clearance, just sufficient to avoid rubbing contact and to allow free running of the rotating parts is provided; the clearance is maintained by a thrust bearing of the marine type connected to the exterior of the pump casing.

Any liquid passing the tightening joint mingles with that in the main flow without appreciably disturbing it on its way to the inlet *A*.

On the rear of each impeller is a balancing chamber *L*, the pressure of which is substantially equal to that in the preceding inlet chamber, as communication is provided through the hub *N*. The liquid under pressure tends to flow from the impeller chamber *O* to the balancing chamber, but it is intercepted by a tightening device, similar to that already described. A multiflange-ring-tightening device *P*, which acts the same as the other tightening devices, is attached to the shaft and under side of the guide shell *D*. The leakage of liquid past this tightening device and the one at the rear of the impeller tends to maintain, in the balancing chamber *L*, a pressure greater than that obtained in the preceding inlet chamber, but the liquid escapes through the hole *M* and, following a narrow passage formed between the end of the guide shell *C* and *D* and the impeller hub, is directed substantially tangentially with and into the liquid current passing from the inlet chamber proper into the inlet *A*.

In Fig. 2 is shown an enlarged section of an impeller and the tightening boxes Fig. 3 is a view of the pump casing. A general exterior view of a steam turbine-driven pump is shown in Fig. 4.

This pump is manufactured in sizes varying from 2 to 24 in., both for single-stage double-suction and multistage types by the Wilson-Snyder Centrifugal Pump Co., 2 Ross St., Pittsburgh, Penn.

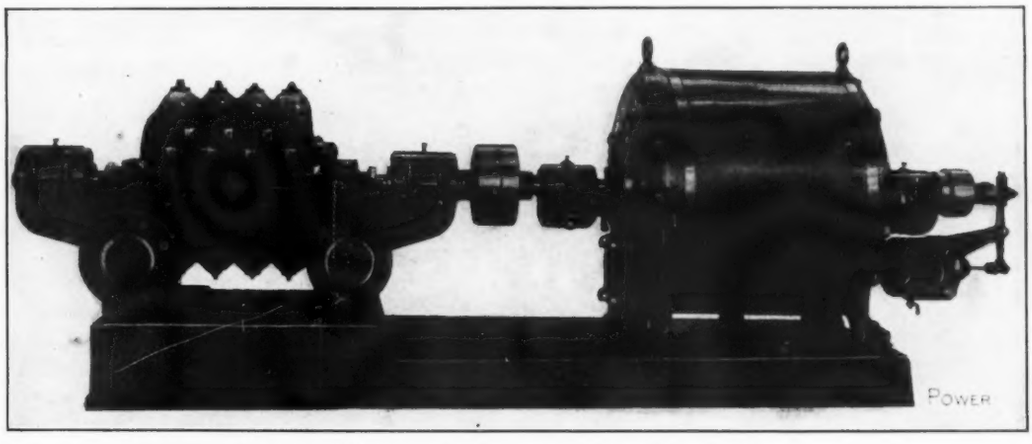


FIG. 4. GENERAL VIEW OF WILSON-SNYDER TURBINE-DRIVEN PUMP

High-Head Water Power—A French company will build in the Canton of Wallis, in Switzerland, a water-power plant, which will have a head of 165 atmospheres, nearly 2500 lb., or 5000 ft. The velocity with which water would be discharged under this head is something like 560 ft. per second, and considerable interest will attach to the type of turbine, which will be used to utilize such a head. It is said that these turbines will be manufactured by a firm in Geneva (probably Piccard Pictet & Co.), while the pipe, which is some 15,500 ft. long, and which requires to be 1¾ in. in thickness at the lower end, will be made by a German firm.

Transmission of Heat through Building Materials

By Frank L. Busey

Since the heating capacity required for a building depends on the amount of the heat losses, it follows that the first step in laying out a heating system is to make a thorough study of the building construction used, and to determine the extent of these losses.

Books giving data on heating contain tables of coefficients, from which one may select factors for the kind of construction which is to be provided for. These coefficients give the heat loss or transmission in B.t.u. per square foot per hour per degree difference in temperature of air on opposite sides of the material. Some of the commonly accepted factors will be found in the accompanying tables. Such factors are fairly reliable when applied to building constructions listed in the tables, but when one is called upon to figure the loss through a wall of a different thickness, or composed of a variety of materials, there is a chance for some tall guessing.

The theory of heat transmission as announced by Peclet has been generally accepted by engineers, and will be found in Professor Carpenter's "Heating and Ventilating Bulidings." According to this theory, the heat transmission from a wall consists of three parts: Radiation and convection from the warm room to the inner surface of the wall; conduction through the material itself; and lastly, radiation and convection from the outer surface. That is, the transmission is due to the two components, radiation and conduction. Although sometimes stated to the contrary, it is evident that a wall of twice the thickness will not have a factor just one-half as great, since the surface loss is the same in each case, and only the loss by conduction is decreased. This part of the total loss (the conduction) does vary inversely as the thickness of the material, but that portion of the heat loss due to radiation from the surface remains the same, no matter how much the thickness is increased.

We are accustomed to think of a wall as transmitting heat, but one may consider the reverse function, viz., its resistance to the transmission of heat. Every form of building construction offers a certain resistance, and the greater this resistance the less will be the transmission. Thus we have the resistance as the reciprocal of the transmission, or the transmission the reciprocal of the resistance. If we consider a 21-in. brick wall with a transmission equal to 0.22 B.t.u. per square foot of surface per hour per degree difference in temperature between the two sides, the resistance of this wall will be

$$1 \div 0.22 = 4.55$$

If we state that the resistance of 2 in. of concrete is 0.80, then the transmission is

$$1 \div 0.8 = 1.25 \ B.t.u.$$

This relation between resistance and transmission holds true both for the conduction and the radiation factors.

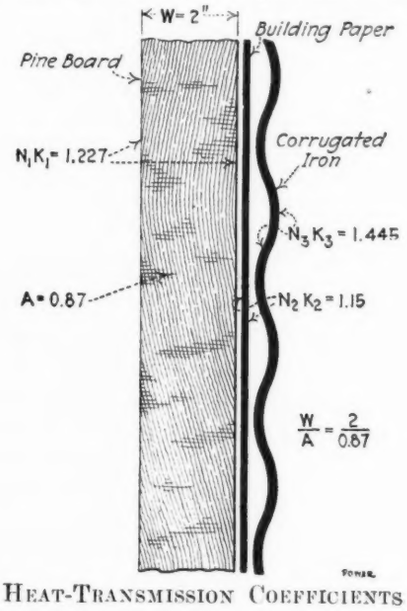
In determining the transmission or heat loss from a wall composed of various substances whose factors are known, it is not correct to add the transmission factors for each substance and call the sum the total transmission of the composite wall, but rather we should find the sum of the resistances of each substance, and the reciprocal will be the factor desired. That is, the factor is the reciprocal of the sum of the reciprocals of the transmission factors of each substance. For example, let us be required to find the proper coefficient for a wall composed of a single thickness of 2-in. pine boards covered with corrugated iron. From the tables of heat transmission we note that the factor for 2-in. board is 0.35, and the reciprocal, i.e., the resistance, is 2.86; and that the factor for corrugated iron is 1.50 and its reciprocal is 0.67. Then

$$2.86 + 0.67 = 3.53$$

is the resistance of the wall and the heat transmission will be

$$1 \div 3.53 = 0.283 \ B.t.u.$$

per square foot per hour per degree difference in temperature between the two sides of the wall. This might be reduced perhaps 10 per cent. to allow for the extra resistance offered by the small air spaces between the board and the corrugated iron. A factor commonly used for this construction is 0.26 B.t.u.



Heat-Transmission Coefficients

The discrepancies between the coefficients given by different authorities are generally attributable to the fact that the values quoted have been determined for different conditions. While the conduction factor depends only upon the thickness of the material, the radiation factor is subject to a number of influences, such as the height of a wall; whether in a horizontal or vertical plane; the difference between the temperatures of its opposite sides and the velocity of air over the surfaces. Thus we see that it makes a difference whether the material is in a side wall or a ceiling; an inside or an outside wall; or whether the surfaces are swept by air currents. While for greater accuracy, especially in cold-storage work, all of these variables should be considered, in ordinary heating work, we may assume that the ordinary coefficients will meet the average conditions.

As mentioned in POWER of Nov. 11, 1913, an elaborate testing plant has been installed at the Pennsylvania State College for determining the effect of these various influences on the rate of transmission. In the article referred to, Professor Moyer shows that in the case of a cork-board cube, by increasing the velocity of the air currents over the surface from 222 to 905 ft. per min., the rate of transmission was increased about 34 per cent. This means a difference of 5 per cent. in the transmission per 100 ft. per min. change in air velocity. The tests reported showed also that an increase of 10 per cent. in humidity caused an increase of 1.2 per cent. in the transmission.

The values of temperature factors N, given in Table 1, for use in connection with the coefficients of transmission will be found to agree substantially with those quoted by leading authorities. The values are based on the assumption that the coefficients given are for a temperature difference of 70 deg. and will decrease or increase correspondingly for a decrease or increase in the temperature difference. This factor N should be applied to the surface or radiation coefficient, and not to that for conduction.

TABLE I. VALUES OF N
For Various Temperature Difference

Difference Between Inside and Outside Temperature	N	Difference Between Inside and Outside Temperature	N
5	0.573	50	0.945
10	0.661	55	0.963
15	0.730	60	0.975
20	0.780	65	0.988
25	0.815	70	1.000
30	0.849	75	1.010
35	0.875	80	1.020
40	0.900	85	1.028
45	0.924	90	1.033

It will perhaps assist in making the foregoing more easily understood if we use a series of equations to show the relation between the various factors mentioned, employing the following symbols to represent the various factors and coefficients.

N = Temperature factor to be applied to the coefficient for surface radiation, the values to be taken from the accompanying table;

NK = Surface transmission for each material;

$\frac{1}{NK}$ = Surface resistance to the transmission of heat by radiation and convection.

The conductivity of any material will vary with the thickness, so that we will have

A = Conductivity of material itself from surface to surface per unit thickness;

$\frac{1}{A}$ = Resistance of the material per unit of thickness to the transmission of heat;

W = Thickness of the material;

$\frac{A}{W}$ = Conductivity of the material;

$\frac{W}{A}$ = Resistance of the material to conduction;

L = B.t.u. transmitted per sq.ft. per hour per deg. difference in temperature between the two sides.

The transmission being the reciprocal of the resistance, then the greater the resistance, the less the heat transmitted, and as the total resistance is composed of the two factors $\frac{1}{NK}$ and $\frac{W}{A}$, we have the transmission in B.t.u. per square foot per degree difference in temperature between the two sides of the material stated by the equation:

$$L = \frac{1}{\frac{1}{NK} + \frac{W}{A}}$$

and the total transmission per square foot per hour with temperatures t_1 and t_2 on the two sides of the materia. will be

$$L_t = \frac{(t_1 - t_2)}{\frac{1}{NK} + \frac{W}{A}} = L\,(t_1 - t_2)$$

In case we are to consider a double wall or a wall made of more than one material, we will have greater resistance due to the extra surfaces adding their resistance and also to the added resistance to conduction, thus giving a lower rate of heat transmission. This will then give us

$$L = \frac{1}{\left(\frac{1}{N_1K_1} + \frac{1}{N_2K_2} + etc.\right) + \left(\frac{W_1}{A_1} + \frac{W_2}{A_2} + etc.\right)}$$

In case the materials considered are very thin, but slight error will be introduced if we neglect the conduction factor and consider only the resistance of the surface. Table 2 gives values for K and A for use in the above equations, and will be found to cover many of the more common forms of building construction.

TABLE 2. VALUES OF K AND A FOR DIFFERENT MATERIALS

Materials	K	A
Brick	1.275	5.50
Brick and 2-in. air space	0.460	5.50
Pine board	1.275	0.97
Oak board	1.275	1.75
Double pine, paper between	0.475	0.97
Sheet iron	1.200	....
Corrugated iron	1.500	....
Pine board and corrugated iron	0.575	0.97
Pine board and sheet iron	0.675	0.97
Single glass	1.095	7.2
Double glass	0.470	....

The application of the foregoing formula may best be shown by a practical example, in which it is required to determine the coefficient of the transmission per square foot per degree difference in temperature for a wall composed of 2-in. pine boards covered with building paper and corrugated iron, with a difference of 55 deg. in temperature between the two sides. From Table 1 we find the value of N to be 0.963.

We will have six surface resistances to consider, NK for the two surfaces of the board being $0.963 \times 1.275 = 1.227$ and for the two surfaces of the corrugated iron, $0.963 \times 1.5 = 1.445$. As the paper and the iron are quite thin, the resistance to conduction would be small and may be omitted for these two materials without serious error.

We will then have the surface resistance $\frac{1}{N_1K_1} = \frac{1}{1.227}$ for the two board surfaces, and assuming the same surface loss for paper as is given for sheet iron, we will have the resistance for the two sides of the paper $\frac{1}{N_2K_2} = \frac{1}{1.15}$. As already stated, the resistance of the two surfaces of the iron will be $\frac{1}{N_3K_3} = \frac{1}{1.445}$. The resistance to conduction of the 2-in. pine board will be $\frac{W}{A} =$

$\frac{2}{0.97}$. Then we will have the total transmission in B.t.u. per square foot per degree difference in temperature between the two sides of the wall as,

$$L = \frac{1}{\frac{1}{1.227} + \frac{1}{1.15} + \frac{1}{1.445} + \frac{2}{0.97}} = 0.224 \text{ } B.t.u. \text{ } per \text{ } hour \text{ } per \text{ } square \text{ } foot$$

TABLE 3. HEAT LOSS FROM BUILDINGS

B.t.u. Transmitted per Hour per Square Foot of Surface per Degree Difference in Temperature

For Various Wall Constructions

Thickness of Board, In.	Pine Board	Double Board, Paper Between	Board and Corrugated Iron	Board and Sheet Iron
½	0.77	0.32	0.45	0.50
1	0.51	0.24	0.36	0.40
1½	0.43	0.19	0.30	0.33
2	0.35	0.16	0.26	0.28
2½	0.30	0.14	0.23	0.25

Constants for Brick Walls

Thickness, In.	Plain	Plastered One Side	Air Space and Plastered	Furred and Plastered
8½	0.37	0.36	0.25	0.23
13	0.29	0.28	0.21	0.20
17½	0.25	0.24	0.19	0.18
22	0.22	0.21	0.16	0.16

For concrete walls add 25 per cent. to the above values for brick.

The values given in Table 3 serve to show how the coefficients for various combinations may be determined, and a table compiled covering any special constructions commonly used.

For cold-storage work the values given in Table 4 will be found convenient, since the factors for resistance and transmission are both given. These factors are based on the results of tests as published by the Armstrong Cork Co. The values quoted for brick and the various materials tabulated down to "hollow tile" are for separate thicknesses of 1 to 6 in. and the values for the rest are for the usual dimensions of the materials referred to.

By the use of the resistance factors, the transmission for various wall combinations may readily be determined. For example, what will be the coefficient of transmission for a wall consisting of 4-in. brick; 2-in. ground cork, and 1-in. concrete? From the table we see that the resistance factors for the above materials are 1.60, 3.49 and 0.667 respectively, and the resistance of the wall will be the sum of the above, or 5.757. The transmission factor will then be

$$1 \div 5.757 = 0.173 \text{ } B.t.u.$$

per sq.ft. per hour per degree difference in temperature between the two sides. This should be increased perhaps 10 per cent. in case of an outside wall exposed to the direct rays of the sun.

TABLE 4. RESISTANCE AND TRANSMISSION OF VARIOUS MATERIALS

B.t.u. per Hour per Sq.Ft. per Degree Temp. Difference

Resistance $\frac{1}{L} = \frac{1}{K} + \frac{W}{A}$ — Transmission $L = \frac{1}{\frac{1}{K} + \frac{W}{A}}$

Material	Thickness of Material—Inches					Thickness of Material—Inches				
	1	2	3	4	6	1	2	3	4	6
Brick	1.00	1.20	1.40	1.60	2.000	1.000	0.835	0.715	0.625	0.500
Concrete	0.667	0.80	0.935	1.07	1.335	1.500	1.250	1.070	0.940	0.750
Pine board	1.83	2.86	3.89	4.92	6.990	0.545	0.350	0.257	0.203	0.143
Ground cork	2.09	3.49	5.00	6.30	9.020	0.479	0.286	0.200	0.159	0.112
Nonp. cork-board	3.85	6.90	9.95	13.00	19.100	0.260	0.145	0.100	0.078	0.052
Ind. fibre-board	2.40	4.02	5.62	7.23	10.44	0.416	0.249	0.178	0.138	0.096
Hair felt	3.23	5.80	8.37	10.25	16.07	0.310	0.172	0.119	0.098	0.062
Mineral wool	1.50	2.07	2.77	3.47	4.87	0.666	0.483	0.361	0.288	0.205
Saw dust	2.63	4.60	6.57	8.52	12.42	0.380	0.218	0.152	0.117	0.081
Hollow tile:										
2 to 6 in.			1.60					0.625		
8 to 12 in.			2.78					0.360		
Air space 1 to 6 in.			0.60					1.66		
Corrugated iron			0.67					1.50		
Sheet iron			0.80					1.20		
Building paper			0.50					2.00		
Tar and gravel			0.50					2.00		
½" slag			0.60					1.67		
½" cement			0.77					1.30		

Building a Smokeless Furnace

By F. A. Shoemaker

The article on this subject, by E. E. Clock, in the issue of Feb. 3, was interesting. The device described was used in the early part of the 80's by Martin, an engineer in Chicago. About two years ago the manager of a local malt-drying corporation claimed his company had recently come into the ownership of a patent covering the same device except that in both of the above cases the three small ducts beneath the grates through the bridge-wall were not used.

I tried the honeycomb wall on top of the bridge-wall some years ago and with careful firing little smoke was produced after the wall became nearly white hot, but it took time each morning to get the wall hot enough to cause perfect combustion. In the meantime, it seemed that before the wall was sufficiently heated there was more smoke than usual without any wall of the kind; besides, the boiler-insurance companies objected on the ground that an 18-in. wall coming in close proximity to the underside of the boiler shell might damage the boiler, particularly at the time of washing out, owing to the heated condition of the wall.

I find it much better to set the boiler at least 36 in. above the grates. I do not carry the bridge-wall more than 14 in. above the grate surface and extend it straight across the furnace. The object is to keep the shell away from the fuel so that when using long-flame bituminous coal, complete combustion will take place before the flame strikes the shell.

The main source of smoke or incomplete combustion is chiefly attributable to a lack of proper knowledge and in many cases to carelessness on the part of the firemen. To get the highest efficiency and to produce the least amount of smoke from any bituminous coal the firemen should be compelled to keep as clean a grate surface as possible as well as a clean ashpit, keep the grates covered at all times with a live open bed of fuel which is not too thick. The class of fuel and its steam-producing qualities will readily determine the thickness of the fire.

It has been found that an almost smokeless result can be obtained with any reasonable high setting if the firemen will follow the above suggestions together with a method of firing something on the following order:

Never place more than two shovelfuls of coal on the fire at a time under running conditions, spreading the two shovelfuls over the rear left-hand quarter of the

grate surface and closing the door quickly. At the next firing place a like amount on the front right quarter, following this by a firing on the front left quarter and the next firing on the rear right quarter, always being careful to leave no holes in the fire or piles of unburned fuel. By taking care to fire this way, giving the fuel an ample amount of air from beneath the grates, it will not only be found that the saving in fuel is in many cases greater than the fireman's wages for a given period, but much better regulation of the steam pressure can be had and little trouble will be experienced in removing soot from the flues. This method applies to the ordinary setting of fire-tube shell boilers in the usual factory plant where the manager is the owner, who, from his multiplicity of other duties, gives very little attention to how the coal is being used, except from the fact that the coal bills always appear to be too high for the amount of power and heat received.

Much of the money that is now spent for fuel could be saved and the smoke nuisance abated if the owner and the fireman would get together and make an arrangement that the fireman was to first keep up a steady, even gage pressure at all times and secondly to share a certain percentage of the fuel saving he could make over the present careless methods. This would give the fireman an incentive to learn his business more thoroughly and treat the coal pile as if it were something paid for by himself and must be handled to the best possible advantage, and to add to these results I have found that the following described setting where the stack or chimney has a reasonable amount of draft makes it possible to operate a boiler with almost no visible sign of smoke from the stack at any time.

One method I have used to prevent smoke is to run three or more small air ducts behind the firebrick lining of the inside walls of the furnace with openings so that the air can enter these ducts just beneath the grate surface, and open the outlet of the air ducts in the side walls to a level with the lowest portion of the boiler shell. The openings in the wall are 4 in. long by 2 in. wide with a 4x4-in. intake beneath the grates and a 1½x4-in. opening where the air enters the furnace compartment.

[Some engineers will, perhaps, disagree with Mr. Shoemaker as to the advisability of a setting having air channels built in the walls to connect the combustion space with the ashpit. We should be pleased to have the subject discussed by those qualified.—EDITOR.]

I had this system installed in one of the largest department stores in Buffalo some years ago with the boilers set 3 ft. 6 in. above the grates. The plant previously burned 100 tons of anthracite egg coal per month, costing $5.55 per ton. Since the installation of this device and with reasonably good firing, the plant has never used over 75 tons per month of bituminous slack coal at about $2.30 per ton, and there is never any perceptible smoke from the stack, except when starting a new fire after cleaning one or the other of the 200-hp. return-flue boilers. With hard coal the engineers were obliged to run both boilers in cold weather, but since using soft coal with this device they never use both boilers at the same time.

The principle of this method is to have a slight blanket of highly heated air in contact with the boiler shell above the fire and bridge-wall, and keep the flame from striking the shell.

This plant has operated under the above conditions for the past five years, the boilers being used for heating and cooking purposes, and the saving in coal bills has been not less than $700 per year and as soon as hard coal went up to $6 and over in this city the saving has been increased over that amount.

The cost of placing these ducts in the furnace walls was less than $100, so it can be readily seen that from the cost of investment compared with money saved by their use that they are a profitable investment.

The question of making tests to ascertain the efficiency of the fuel has been suggested to parties using this method, but they have objected to either having or permitting any tests being made, stating as their reasons that the saving in fuel cost over the old method has given them sufficient record of what is being done and they do not care to have an efficiency test run.

It is strange that after so many years of power-plant engineering, mechanical engineers find it hard to convince the owners of boilers that, by a small investment at the start, they can eliminate smoke and get much higher efficiency from their power plants, having the original investment returned to them many times. The fact is it takes so much time to convince a client of this fact that the returns to the engineer are unprofitable, but still we keep at it, hoping some day to convince a sufficient number of power-plant owners so that the others will appreciate the value of high settings and need no elaborate proposals to convince them that they should use such settings.

The Cost of Power-Plant Equipment and Supplies

Data bearing upon the cost of power-plant apparatus, supplies and construction materials are often useful to engineers who are obliged from time to time to prepare estimates of the expenses of plant extensions, new construction or alterations. Some material of this character is presented in the following tabulation, the costs being obtained from a Massachusetts steam-driven station, supplying electricity to a population of about 100,000 people. The costs printed are accurate, although they are necessarily rather miscellaneous, as only those items have been given which are likely to be useful in the preparation of estimates. Many small supplies are included, but the engineer who desires to make use of the figures will have no difficulty in classifying them or transferring them to card indices as desired.

REPRESENTATIVE POWER-PLANT EQUIPMENT COSTS

Four stokers for four 400-hp. Porcupine boilers, Murphy Iron Works	$6,900.00
Four 400-hp. Porcupine boilers with 52-in. stacks	20,700.00
Brick setting for above stokers and firebox	2,000.00
One 4500-kw. Parsons turbine, including exciter, priming pump and Le Blanc condenser, Westinghouse Electric & Manufacturing Co	45,000.00
Fifty direct-current, 5-amp., constant-series, inclosed arc lamps, General Electric Co	1,125.00
Fifty electrodes for above type of lamps	3.00
One 10,000-volt, Weston dial voltmeter, complete, for arc service	268.38
One special 5-amp., 75-light, 60-cycle, form BWZ, General Electric Co., combined unit-mercury arc-rectifier outfit, with cylinder and transil oil (50 gals. No. 6 latter), one switchboard panel, lightning arrester and iron drum	1,777.65
Six extra rectifier tubes	120.00
Two No. 70 Ward, Drouet & Foster potheads	16.55
Two hundred bricks	1.45
Three 100-amp., 5500-volt, Condit oil switches and fittings	91.20
One barrel of grease	18.80
One 75-k.v.a., 60-cycle, 440-volt Westinghouse transformer, oil and hanger irons	360.00
One 100-amp., 2500-volt Condit circuit-breaker	27.95

Three hundred and fifteen feet 2x12-in. spruce boards	9.90
One hundred and forty-four gallons "Minerallac"	172.80
Forty-eight feet 6x8-in. spruce boards	1.34
Two ½x12-in. machine bolts	0.15
Ninety-seven feet 4-in. cypress lumber	16.76
One bag asbestos cement	1.75
One barrel hard grease	21.00
One thousand brick	10.00
Two 75-amp., 110-volt General Electric Co. meters	38.03
Two 150-amp., 220-volt, 60-cycle, General Electric Co. type "I" meters	75.60
Twenty-five 5-amp., 110-volt meters	253.13
One 14-in. Lagonda strainer	440.00
One 20-in. Lagonda strainer	660.00
One hundred 1x6-in. machine bolts	10.20
One 10-in. angle valve, Star Brass Manufacturing Co	162.00
Four 2½-in. brass globe valves, Star Brass Manufacturing Co.	138.00
Twenty-five bags cement	11.25
One hundred and twenty square feet asbestos wood, for switchboard work	19.20
Fifty switchboard-card holders	26.00
One 1½-in. Watson-Stillman "Levo" pump, 60-cycle, 220-volt Wagner motor	210.00
One Bristol recording thermometer	107.20
One Catchall (Hohmann & Maurer) vacuum gage	85.00
One hundred feet ½-in. iron pipe	4.10
Two hundred and twelve feet 6-in. iron pipe and six ells	5.76
One 7-in. Chapman iron gate valve	16.50
Two Argand steam blowers	79.55
One hundred 1x⅜-in. machine bolts	0.60
One hundred and ten ft. ½-in. tiller rope	10.01
Forty feet ½-in. hoisting cable	2.04
One General Electric Co. steam-flow meter, size not stated	75.00
Eight bars 2x2x¼-in. angle iron	10.00

International Engineering Congress, 1915

The attention of the engineers of the world is being more and more drawn to the program of the International Engineering Congress to be held in San Francisco in 1915. The interest aroused in foreign countries is shown by the fact that at the present time there have been received enrollments and subscriptions from 42 countries. Furthermore, the present total enrollment, approximately 25 per cent. is from countries other than the United States. The number of subscriptions from the members of the five national engineering societies of the United States is, however, not so gratifying. The percentage of the total membership represented by the subscription list is only 3.7, and this, although each individual member has received circular information and data concerning the Congress and has been urged to send in his subscription promptly.

It is probable that this is largely because the Congress is still somewhat in the future, and also to the tendency of the individual to procrastinate. This, to a considerable degree, handicaps the work of the committee on management, and it is extremely desirable that as many as possible who intend to subscribe should do so at an early date.

The list of topics to be treated in the section on mechanical engineering gives a very good idea of the character of the publications which it is intended to issue. These are as follows:

Recent progress and present status of foundry practice, and casting metals; Recent progress and present status of the art of forging; Equipment processes, and methods for the boiler shop; Machine-shop equipment, methods, and processes; Automatics; Special processes for shaping and forming metals; High temperature flames in metal working; Industrial management; Safety engineering; Industrial museums as an educational factor; The steam engine of the year 1915; The steam turbine of the year 1915; The internal-combustion engine of the year 1915; Motors of the Diesel type; The Humphreys gas pump; The steam boiler of the year 1915; Refrigeration; Pneumatics; Lubrication and lubricants; Waterwheels of pressure type; Waterwheels of impulse type; Hydraulic power developments and use; Power-plant design; Motor vehicles, passenger type; Motor vehicles, utility type; Motor tractors.

Many of these topics will be treated as symposiums with contributions representing the practice in more than one country.

The various sections outlined for the work of the Congress and the volumes to be issued are as follows:

Vol. I, The Panama Canal; Vol. II, Waterways and Irrigation; Vol. III, Municipal Engineering; Vol. IV, Railways and Railway Engineering; Vol. V, Materials of Engineering Construction; Vol. VI, Mechanical Engineering; VII, Electrical and Mechanical Engineering; Vol. VIII, Mining Engineering and Metallurgy; Vol. IX, Naval Architecture and Marine Engineering; Vol. X, Military Engineering, and Miscellaneous.

Vol. X will consist only in part of Military Engineering, and will also contain papers on miscellaneous topics which are not definitely associated with any of the various sections. Full information concerning the congress may be obtained by addressing the International Engineering Congress, 1915, Foxcroft Building, San Francisco, Calif.

New England Association of Commercial Engineers

The New England Association of Commercial Engineers was organized at Worcester, Mass., July 12, 1911. It is an association of individuals to which are eligible business men, inclusive of executives, officials and salesmen affiliated commercially with power-plant engineering in New England. From 47 charter members the membership has grown until, at present there are 214, representing some 180 business firms.

One of its principal objects is to bring together representatives of different industries in the power field and devise ways and means of increasing the business of the engineering lines in New England. Association is always helpful, and the members have found that by becoming acquainted with each other it has resulted to their mutual benefit. Although competitors in the same line of apparatus are brought into social contact, and competition is as keen as ever, it is on a cleaner and more wholesome basis.

Another object is to bring the users and the selling end of power-plant equipment and machinery more closely together, and to obtain more consideration for the commercial engineer who represents the selling end. The members have the opportunity, which they do not neglect, of helping the operating engineer in working out problems which are up for solution, by volunteering information on the line in which he is interested.

There is another way in which the members are benefited. In the routine of business a member is bound to hear of the proposed installation of some device or machine which is handled by another member. The logical thing to do is to notify the former of the prospective new business, and to advise the prospective purchaser of the name of the member and the firm he represents, who handles the particular apparatus desired. This also helps the engineer in getting in touch quickly with the firm which can supply his requirements. This coöperation offers an opportunity to do away with friction, which retards progress in any line of endeavor, eliminates prejudice and opposition and helps to overcome obstacles which stand in the way of business progress.

The commercial engineers realized early in their career that the facilities for getting business must be given attention, and from the first set about conducting a power show, where it was possible to meet those who were interested in power-plant apparatus. The first show was held in Mechanics' Building, Boston, during one week of April, 1912, when over 125 manufacturers of power-producing machinery, specialties, supplies and accessories were represented, and when thousands of engineers and others interested in power-producing mechanics visited the exhibits.

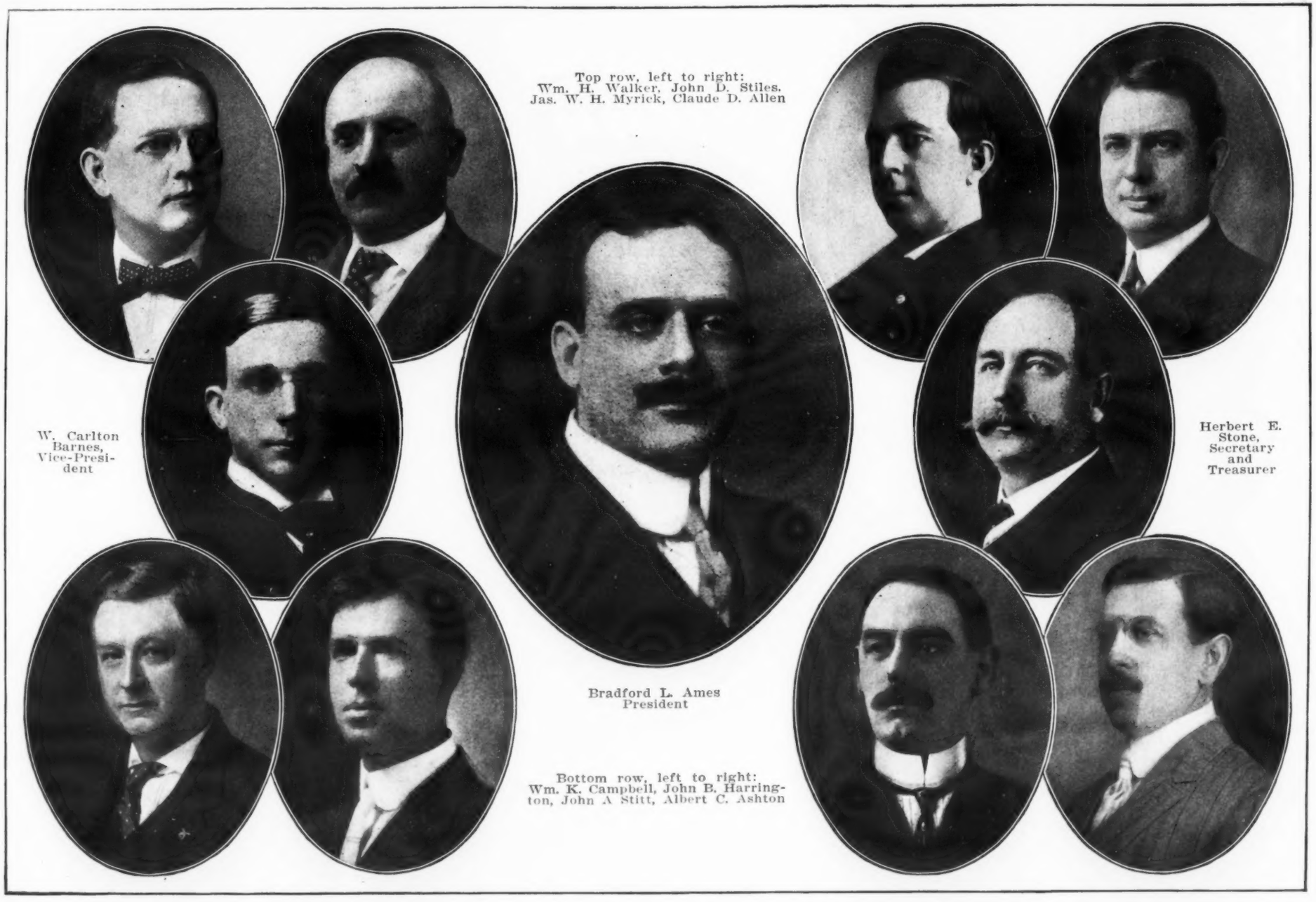
A second show was held in Northampton, July, 1912, in connection with the Massachusetts Association of Stationary Engineers' state convention, when about 70 exhibitors displayed their products.

As another means of getting in touch with new business, a news bureau was established on June 3, 1912, with 25 members. Members of the association were privileged to contract for the news-bureau service by paying $1 a week. The bureau furnishes clippings from 40 to 50 local daily newspapers published in New England from government bulletins and foreign trade reports, and also keeps in touch with the offices of consulting and contracting engineers, architects and municipal building departments. News notes are also received through members of the association and from special correspondents stationed in New England. All information is transferred to a daily report sheet in letter form and mailed each day to the subscribers.

As a help to sustaining the coöperation feature of the organization, a monthly bulletin is published and monthly luncheon meetings are held. The bulletin is a four-page sheet in which are published business reports, notices and news notes, especially pertaining to the business matters of the association. At the luncheon meetings, when time permits, after transacting the business of the association, prominent men have been secured as speakers.

Another power show will be held in Mechanics' Building Apr. 27 to May 2, in connection with the Textile Exhibitors' Association's fourth national textile exhibition.

The power-show committee is headed by Claude D. Allen, which is an assurance that with the assistance of his able


Top row, left to right:
Wm. H. Walker, John D. Stiles,
Jas. W. H. Myrick, Claude D. Allen
W. Carlton Barnes, Vice-President
Herbert E. Stone, Secretary and Treasurer
Bradford L. Ames
President
Bottom row, left to right:
Wm. K. Campbell, John B. Harrington, John A Stitt, Albert C. Ashton

OFFICERS AND DIRECTORS OF THE NEW ENGLAND ASSOCIATION OF COMMERCIAL ENGINEERS

coöperators, Messrs. Myrick and Warren, the coming exhibition will be most successful. The booths assigned to the association will be in the power department, convenient to all of the 150,000 and more spectators who are expected to attend.

For the benefit of those interested, the association has got out a business directory of members which not only gives the names of the officers, directors and members of the committees, but also has a list of the members with their address and a directory of concerns and representatives.

The office of the association is in the Equitable Building, Boston, Mass. Bradford L. Ames is president, and Herbert E. Stone is acting secretary.

Old Employees Get Pensions

After long service the following employees have been retired and pensioned by the Consolidated Gas, Electric Light & Power Co., Baltimore, Md.: Robert Wright, 41 years' service; Robert J. Korr, 40 years; William H. Gallagher, 37 years; Jacob H. Griffin, 36 years, and John Rodgers, 21 years.

The system of retirement now employed by the Baltimore central station was planned by President J. E. Aldred and has been found to exert an excellent effect. The five men recently retired on pensions have been also put on the company's roll of honor and were recently presented silver medals in token of their long careers of usefulness and fidelity.

Alabama Power Co. Installs First Unit

The Alabama Power Co., the principal operating company of the Alabama Traction, Light & Power Co., has completed the installation of the first of the four 17,500-hp. generating units at its hydro-electric plant on the Coosa River, at Lock 12. This unit is the largest of the single-runner type yet installed in a hydro-electric station and is the first of a 70,000-hp. development being made at Lock 12.

The construction of the dam makes a long stretch of the Coosa River navigable and it is estimated that the operation of the plant will save 500,000 tons of coal a year in the community.

Big Power-Plant Project Halted

In a decision reversing the opinion of the superior court of Skagit County, Wash., the supreme court of Olympia recently dismissed certain condemnation suits instituted by the Western Washington Power Co. against land owners along the Baker River and its tributaries. The court held that the testimony did not show sufficient cause for the exercise of the power to condemn private property for public purposes.

As a result of the decision, the plan to erect a big hydro-electric-power plant in Skagit County will be temporarily halted. The attorney for the Western Washington Power Co. will prepare a motion for a rehearing of the case by the supreme court. The testimony showed that it was planned by the power company to submerge several hundred acres of land by the erection of a dam 224 ft. high. The interest of the co-partnership of Stone & Webster was shown in the evidence and not denied, but the supreme court held that the Western Washington Power Co. was organized to do by indirection what the copartnership could not legally accomplish under the laws of the state, relating to the right of condemnation of private lands.

ENGINEERING AFFAIRS

The Pittsburgh Association of the National Association of Stationary Engineers was shown the process of making tubing "From Ore to Finished Pipe" in the assembly room of the Fulton Building, Mar. 9, the lecturer being W. A. Phillips of the National Tube Co.

W. A. Converse, chemical director for the Dearborn Chemical Co., recently completed a series of lectures on the subject, "The Ill Effects of Boiler Waters and Their Causes," before Eastern associations of the N. A. S. E. and the A. O. S. E. The places visited were Perth Amboy, Jersey City, Newark, Trenton, N. J., and New Haven, Hartford, Philadelphia, Baltimore and Reading, Penn.

The American Society of Engineer Draftsmen and the Technical League of American have been consolidated as the Technical League of America. The officers of the consolidated Society are: President, Charles William Weick; secretary, Walter M. Smyth. The headquarters are at 74 Cortlandt St., New York City.

The second International Congress of Consulting Engineers will take place in Bern (Switzerland) in 1914. At the first congress, which was held in 1913 on the occasion of the Universal Exhibition at Ghent, an International Federation of Consulting Engineers was founded for the purpose of uniting societies already in existence in a great number of countries; of assisting in the formation of similar organizations where none has yet been established and, finally to establish a bond which should prove extremely advantageous, between consulting engineers throughout the entire world. The provisional program includes the survey of many subjects connected with the professional interests of consulting engineers. It is the purpose to hold the third congress in San Francisco in September, 1915, during the exposition.

The "visitor's night," on Wednesday evening, Mar. 25, of the industrial arts department of the Ohio State University was most successful, about 1000 persons visiting the shops, largely mechanics. Invitations were sent through the shop superintendents, whose coöperation greatly helped in bringing the exhibition to their attention. The students were in the shops and engaged upon the work they ordinarily performed during the daytime. The object of the two-year industrial course taught by the university is to give the student a fundamental technical training under practical instructors. The first year includes elementary algebra; plane and solid geometry; trigonometry; freehand and mechanical drawing; lettering; pattern-making; forging; founding; bench work in metal. The second year, descriptive geometry; machine sketching; mechanical movements used in machines; elementary physics; strength of materials; machine-tool practice.

PERSONALS

Quincy A. Hall, formerly engineer of tests of the Isthmian Canal Commission, has associated himself with the Morgan T. Jones Co., Chicago, as secretary and engineer of tests. Mr. Hall is a graduate in mechanical engineering from the University of Illinois, and recently resigned his position with the Commission after over six years' service in the mechanical department.

O. P. Wilson, of the purchasing department of the Westinghouse Electric & Manufacturing Co., has resigned to become the assistant general manager of the Norma Company of America, 20-24 Vesey St., New York City, manufacturers and importers of ball bearings, precision instruments, etc. Mr. Wilson was with the Westinghouse Co. for 14 years and for the last ten years was one of its head buyers.

OBITUARY

KERAN GUNNING

Keran Gunning, a retired engineer, died of general debility on Friday, Apr. 12, at his home, 89 Walworth St., Brooklyn. He was 60 years old, and a member of the National Association of Stationary Engineers and the Brooklyn Veteran Firemen's Association. He leaves two sons and two daughters.

BOOKS RECEIVED

ENGINEERS' COSTS AND ECONOMICAL WORKSHOP PRODUCTION. By Dempster Smith and Philip C. N. Pickworth. Emmott & Co., Manchester, England. Cloth; 248 pages, 5½x8¾ in.; 32 illustrations; tables. Price, 4s. 6d.

GEAR CUTTING. By Joseph G. Horner. Emmott & Co., Manchester, England. Cloth; 391 pages, 5½x8¾ in.; 367 illustrations; tables. Price, 7s. 6d.